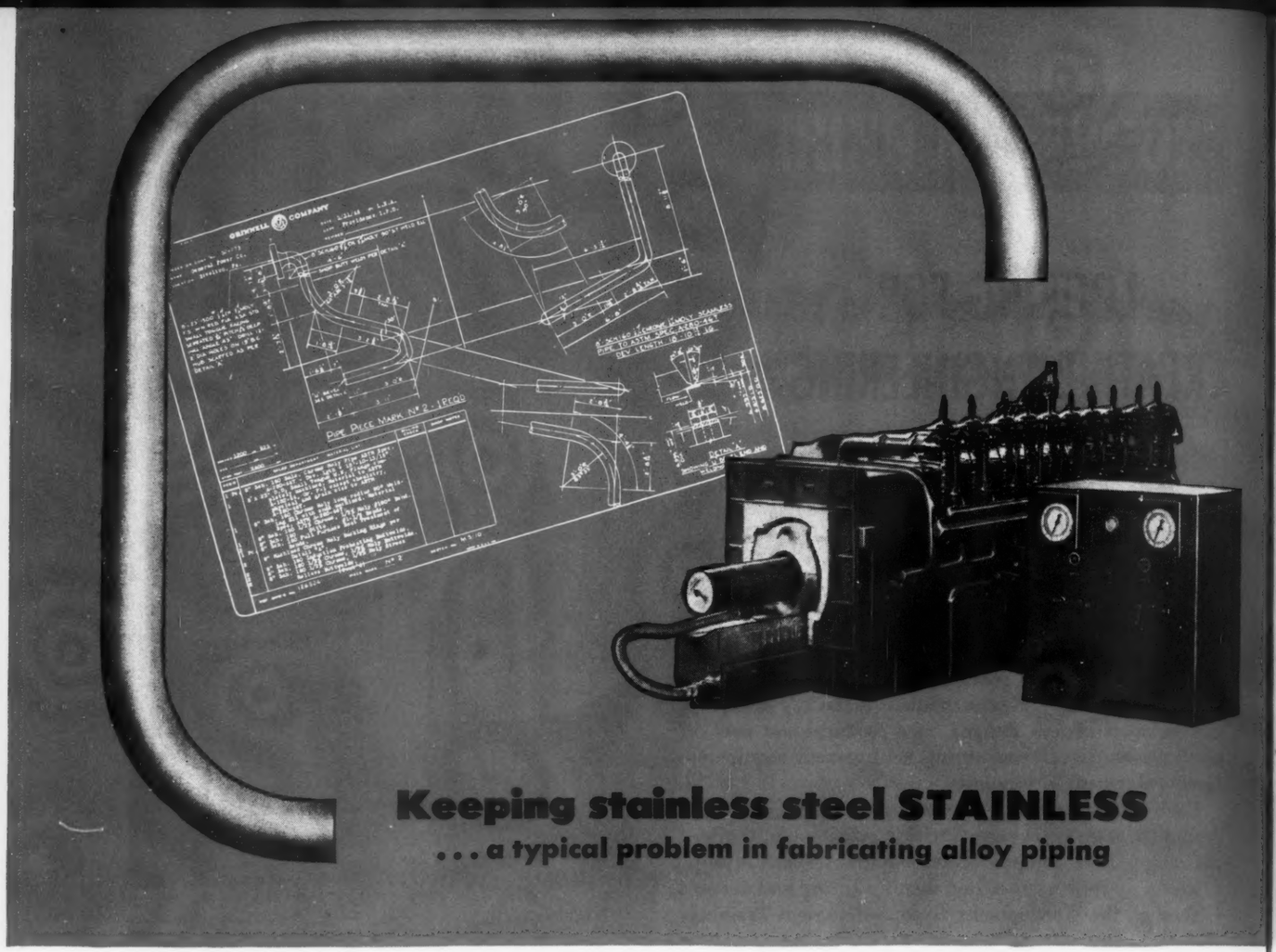
march, 1949
tech engineering news
Sibley Dome



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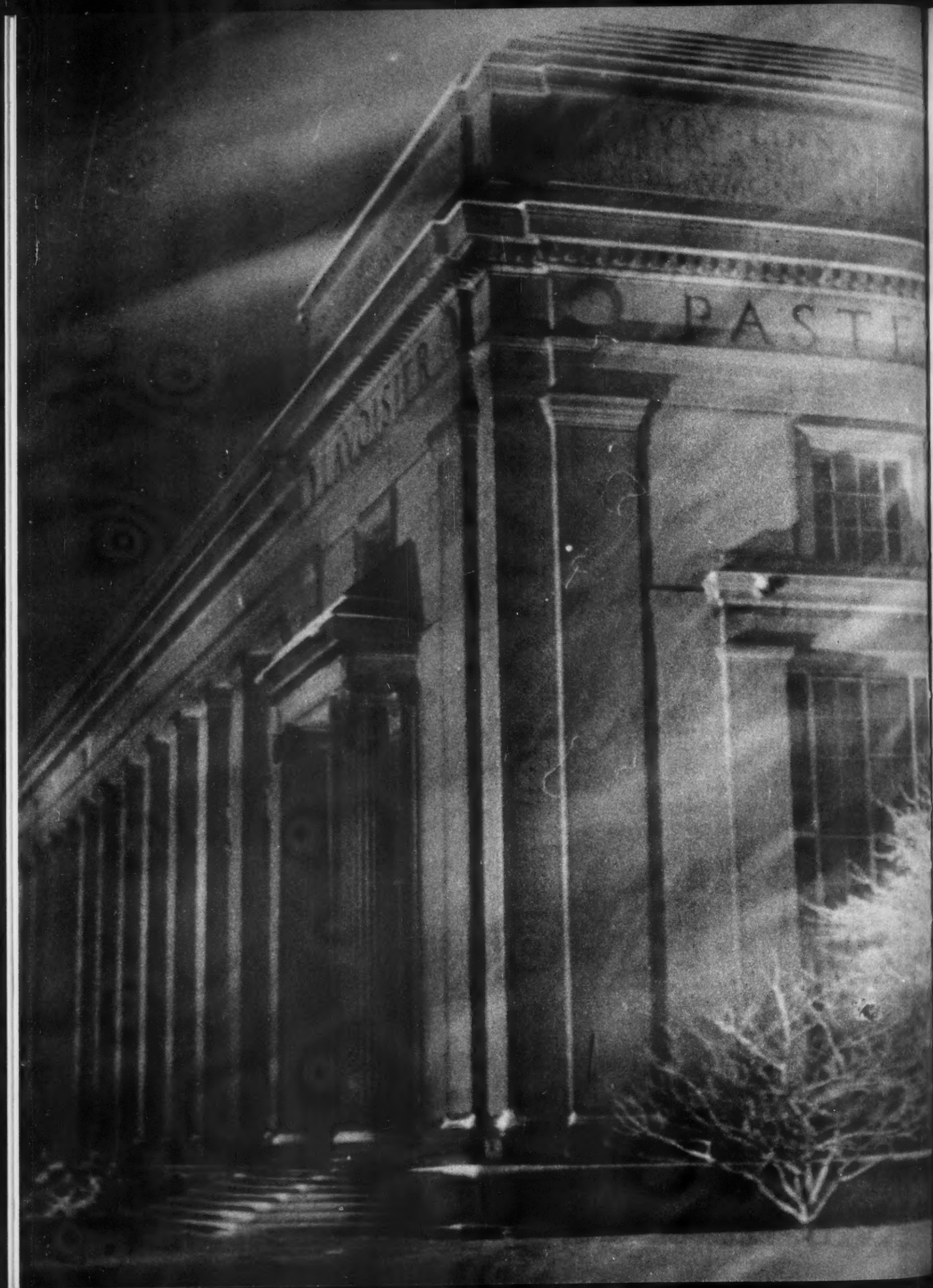
PASTE

the tech engineering news

March 1949

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wiener—paul bunyan of m. i. t.

By Milo Backus, '52

"Arriving late at his M11 class one morning, Professor Douglas found Dr. Wiener already lecturing to the class. Professor Douglas went to the rear door of the classroom and sat down in the back row. Dr. Wiener was discussing a problem from M22 which none of the students in the room seemed to understand. He talked on for fifteen minutes. Then, looking more closely at the front row of students, he suddenly realized that he was in the wrong classroom. Without a word he picked up his books and papers and stormed out of the door."

Such stories about the absent-mindedness of the Doctor have become part of tradition here at Tech; but, when you see Professor Norbert Wiener walking about the halls and absent-mindedly scratching his right earlobe, you can be reasonably certain that he is considering some mathematical profundity which we would find quite difficult to comprehend. Showing genius in mathematics since the age of six, Dr. Wiener has long been considered one of the world's outstanding mathematical analysts.

The Professor is almost as famous for the breadth of his knowledge, investigations, and overall scientific outlook. With the belief that sciences today are too specialized, he studies and lectures in a variety of subjects. He is a philosopher, a literary scholar, and an exceptional linguist, fluently speaking half-a-dozen European languages and "of course, Mandarin Chinese." More than a hundred of the cards in the Central Library bear his name as author; and, at present, he is working on at least five different books, ranging in subject from the "Dynamics of the Nervous System" to detective fiction.

His latest book, "Cybernetics," originally published in Paris, France, has been hailed as a revolutionary contribution to science. Cybernetics represents the meeting point of control and communications engineering, neurophysiology, and psychology. Dr. Wiener compares the functions of control mechanisms, such as thermostats and governors, to the nerve mechanisms of the human brain. Through this new science, machines could replace the human mind, at least in routine operations, just as machines now replace human muscles; taking the social effects into account, the book points out that such an accomplishment could lead to a society which could gain nothing from the average individual, his mind and muscles having been replaced by machines. The basic idea of cybernetics, developed through the collaboration of specialists in several different fields, originated with Dr. Wiener's World War II work on computers that predict an airplane's course and point an anti-aircraft gun in a corresponding direction. Out of this work he came to the conclusion that many of the inventions going into robots had been used all along, quite unconsciously, by the nerve mechanisms of the human brain.

Along with cybernetics, Dr. Wiener considers his work in developing the generalized harmonic analysis theory and his work with Tauberian theorems to be his most significant contributions to science. Dr. Wiener is a prominent member of the London Mathematical Society as well as the American Mathematical Society.

Dr. Wiener began his mathematical career because of an unsatisfactory grammar school report card. When his father, a Harvard professor of Slavic languages, saw the low mark in arithmetic, he took his son in hand, and, after a few months, Dr. Wiener found that the subject was easily understood. "It was just laziness from that point on," he says, "for I knew that it would take less work to specialize in math than in any other subject." His choice was strengthened when he looked more deeply into the subject, for he "found it much easier to think algebraically instead of arithmetically."

The Professor relaxes at home with some "light" reading — the Encyclopedia Britannica.

The Professor was born in Columbia, Missouri, in 1894 and was brought up here in Cambridge, Massachusetts. With the help of his father, he sailed through the rest of his schooling. He entered a public high school at nine, emerged at eleven, and had his A.B. degree from Tufts when he was thirteen. Studying biology and philosophy as well as mathematical logic, he received his Harvard Ph.D. when he was only eighteen. He then went to Germany and England for post-graduate work in mathematics and philosophy. Rejected from service in World War I because of his poor eyesight, he worked first at the General Electric Company at Lynn, and then in Albany for the Encyclopedia Americana. His job was terminated in 1919 by a telegram calling him to the Aberdeen Proving Grounds where he served as a computer, first as a civilian and later as a buck private. Immediately after the war, he became a feature writer on the *Boston Herald*. In 1919, he joined the faculty of MIT, "at a time when the returning flood of veterans was swamping the universities, and when anyone with any teaching qualifications was avidly sought to take care of the pressing need." Because accordingly he really had to work his way up to achieve his present position here, Tech means a great deal to him.

In Göttingen and Copenhagen in 1926 on a Guggenheim fellowship, he met his wife, Margaret Engemann, who was also a teacher. In 1931, he lectured in England. In 1935, he acquired his knowledge of Mandarin Chinese while serving as a visiting lecturer in the Tsing Hua University in Peiping, China. He has worked for several periods at the Instituto National de Cardiologia de Mexico with the support of the Mexican National Research Council and the Rockefeller Foundation. Under this plan, which is still in operation, he has done much of his work with Arturo Rosenblueth on cybernetics.

When Dr. Wiener has a vacation, he can often be found at a New England skiing lodge. "I'm not a very good skier," he says. "I'm the type that goes to a skiing lodge and then gets out and walks around on the skis." The Professor was an ardent mountain climber until a couple of years ago and is still a member of the Appalachian Mountain Club. "I was a fair climber," he says, "but now I'm out of shape." He's still interested, however, and may resume his climbing in the near future.

Dr. Wiener's character is just as admirable as his intellect. Mrs. Margot Zemurray, his secretary, who in the past four months has become quite closely acquainted with him, gave the following impression of his character:

"Dr. Wiener is the kindest, most understanding person I've ever come in contact with. He is extremely concerned with the welfare of the human race. He is witty, humorous, and generally good-natured, although he sometimes has a good healthy attack of temper. He is generous to the people working with him. He is not conceited about his high position in science but is rather humble. He is a very lovable person."

When I walked into Dr. Wiener's office for my interview, he was engaged in a very intense discussion on international affairs with another professor. After a few minutes of heated argument, he saw his visitor to the door, laughing and joking. After he had been out of the door for about a minute, his secretary rushed out after him saying, "I'd better catch him before he wanders away." When he came back, Dr. Wiener told me to sit down, heard my purpose, and then quickly and logically ran through his life history. He was very frank and sincere in everything he said. When I asked Dr. Wiener about the anecdotes I had heard about him,

Ranging around Dr. Wiener are daughter Peggy, a Chem major at Tufts, Mrs. Wiener, and daughter Barbara, a B.U. graduate who is now serving as a staff writer for *Science Service*, a Washington feature syndicate. Oh yes, and don't forget feline Mr. Bennet.

he said, "I am absent-minded. Some of the stories about my absent-mindedness are true. But I've heard the stories so many times that I'm sick of them." Now and then he would put in a joking remark, and he seemed to enjoy himself immensely. In every respect the Professor corresponded to the description Mrs. Zemurray had given us.

Much of Dr. Wiener's time is spent in discussions of all types of problems. He can often be seen just sitting in his favorite chair in his office thinking. When he becomes tired he dictates one of his mystery novels to his secretary. He has already completed one full-length novel, "A Life of Science." I asked the Professor about the plots of his gangster stories but was rebuffed with the statement that "a mystery novel is something not to be disclosed until finished." However, he did give us the hint that one of his mysteries has a "white mountain in the background," and that the other book has a medical background.

Of the many anecdotes told about the Professor, these are two of the most interesting:

"A student in Dr. Wiener's M22 class had had

(*Continued on page 188*)

hot air goes to work

By Alex Bloch, '50

New Developments of an Old Idea

All of us are familiar with the fact that a gas when warmed expands and, conversely, contracts when cooled. This principle, known to scientists and engineers for a great many years, was thought to be applicable towards the construction of an engine even a long time ago. Indeed, in 1816 Robert Sterling received a patent for the first air engine and his pioneer work has been used in recent years by the Philips concern in the Netherlands in the construction of a highly efficient and promising engine.

Let us first look at the whole idea of an air engine and the way we can make it work. Imagine a cylinder, open at both ends, divided into two parts which are connected to each other, with each part containing a piston (Fig. 1). One part is kept at a high temperature and we call it the hot space and the other part is at a low temperature — the cold space. A certain fixed quantity of air will be enclosed between those pistons. For reason of simplicity let us also assume that the high and low temperature spaces are at fixed temperatures T_1 and T_1 respectively. We can now start on the cycle. The air is arbitrarily altogether in the cold space at Temperature T_2 and occupying maximum volume V_1. This will be state 1. Going from here to state 2 the air is compressed by the piston in the cold space to minimum volume V_2, the temperature remaining constant. We now proceed to state 3 by moving the air still at volume V_2 to the hot space where its temperature increases to T_1. At state 4 the air in the hot space expands again to maximum volume V_1. From here we come back to our original state 1 by displacing the air at constant volume to the cold space where it is cooled down to T_2. This cycle can now repeat itself over and over again and we see that it can be applied to an actual engine.

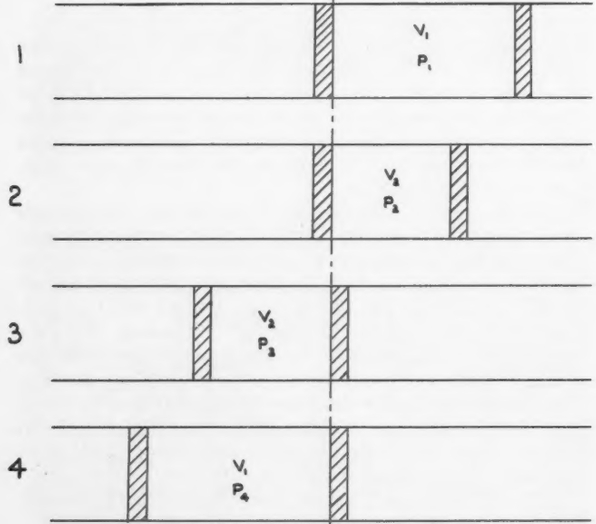
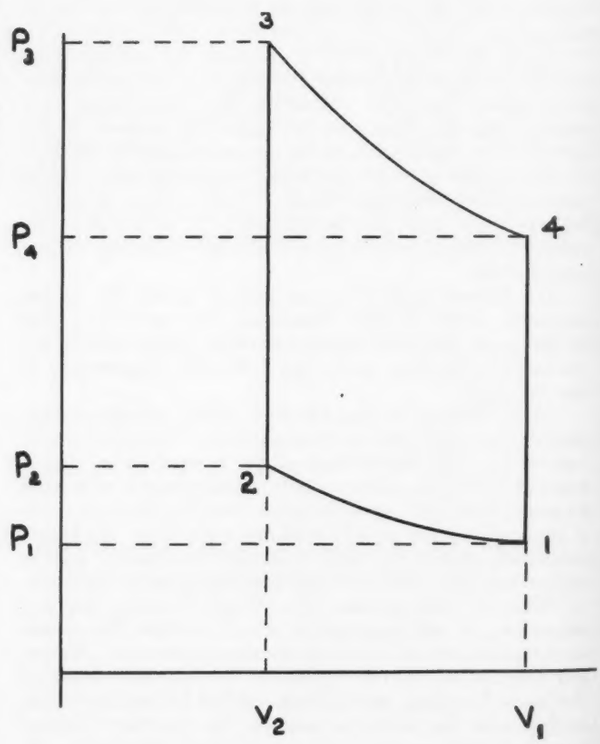


FIG. 1

In order to make this engine a working one, which means converting heat into mechanical energy, a surplus, or net, work has to be obtained. We see in the above cycle that when going from stages 2–3 and 4–1 no work has been done at all and hence we do not have to consider these stages in our analysis. All that remains are therefore stages 1–2 and 3–4. Here we see that the air is being compressed during stage 1–2 and work is being done. This work however takes place at a low temperature and consequently low pressure. When expanding the air during stage 3–4 work is being produced, and since we are now at a higher temperature and therefore higher pressure, this work will be greater than that when going from 1–2. The difference in these works will be our net gain.

For those who are familiar with basic thermodynamics the accompanying p-v diagram (Fig. 2) will show the gain in net work readily. Work is equal to the area under the curve and hence net work will be represented by the area of 1–2–3–4–1. In short, and this is the fundamental principle of the air engine — net work is obtained because isothermal expansion of



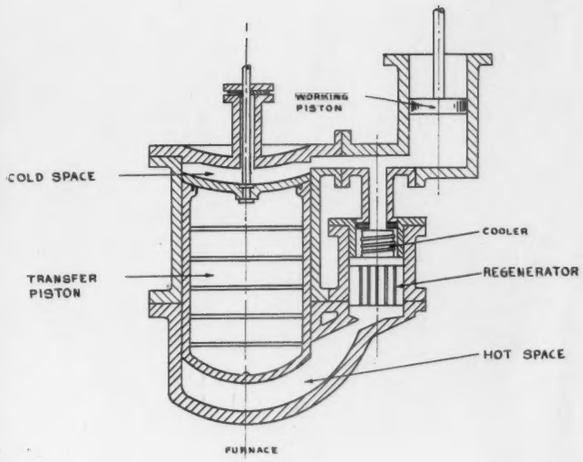


FIG. 3

the air takes place at a high, and isothermal compression at a low temperature.

As I said before, as far back as 1816 a patent for an air engine was given out: it was subsequently developed somewhat and the accompanying drawing (Fig. 3) represents a section through one of Sterling's later models, about 1940. The whole machine is indeed quite simple and very ingeniously constructed. The essential parts are just the working piston, the transfer pistons and their respective cylinders. Tracing through a cycle of operation of this engine we will see at once that it follows closely that of the imaginary air engine discussed above. Air is compressed in the cold space by the downward movement of the working piston. The transfer piston then moves up and displaces the air into the hot space. There its temperature increases and the higher pressure produced is transmitted to the working cylinder, thereby raising the piston and thus doing useful work. The transfer piston next descends and brings the air again into the cold space and we are ready for another cycle.

We will notice in Fig. 3 the term regenerator. This is not an essential part of the engine, but increases its efficiency greatly. It simply is a device to store heat, which would be wasted otherwise. The hot air which passes through the regenerator leaves a part of its heat there, which the cold air, when passing through, picks up later.

However, with the limited technological facilities available at that time, the efficiency of the Sterling engine was extremely small, less than one per cent, and the weight per horsepower developed much too great to be of any economical use. With the invention of the internal combustion engine the old air engine slipped into obscurity and was forgotten. I should rather say it was forgotten till about ten years ago when some engineers of the Philips concern were looking for a light engine. Among other prime movers suggested for research was the old Sterling air engine. The striking fact about this engine is that its theoretical efficiency is extremely high, and with modern methods and technique at hand, it was a very promising investigation.

Now we go back to our imaginary air engine, but this time introducing an ideal, *i.e.* one hundred per cent efficiency, regenerator. We will notice that we have here an equivalent reversible cycle, and by thermodynamics its efficiency is equal to that of a Carnot cycle, which is $\frac{T_1 - T_2}{T_1}$. Using practical temperatures of T_1 - 1000 F. and T_2 — 130 F. we will obtain an ideal efficiency of sixty per cent. It is obvious that this maximum efficiency is unobtainable owing to mechanical friction, the fact that the expansion and compression are not executed entirely isothermally, heat losses, and imperfect regeneration. However, taking all these into consideration we should still be able to obtain efficiencies larger than those of corresponding gasoline or Diesel engines.

Let us consider what could have been done to the old air engine to bring it up to modern requirements. Of foremost importance in the air engine is the regenerator. In the old Sterling engine it simply consisted of some sheets of metal which had an extremely small efficiency. Today we have regenerators having close to 95 per cent efficiency. These are made from metallic wire spun in a coil. The wire thickness is approximately 1/2000 inch and is able to raise the temperature of air flowing through it from 200 F. to 1100 F. within 1/100 of a second. Developments in the field of metallurgy made possible the use of lighter alloys for overall construction and increasing temperature working range, thus giving obviously a higher efficiency. Develop-

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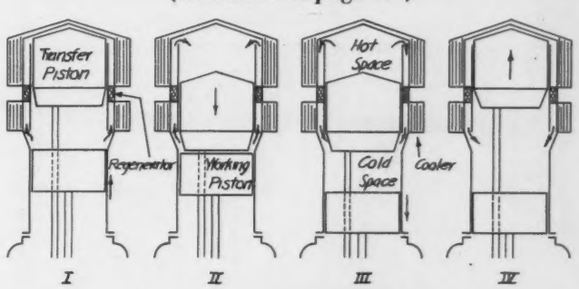


FIG. 4

Cycle of Air Engine

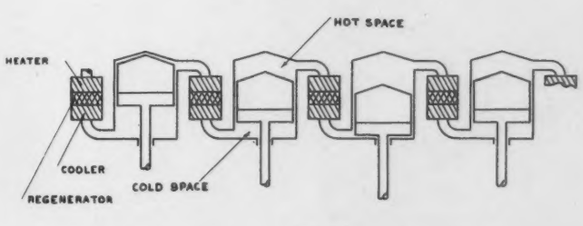
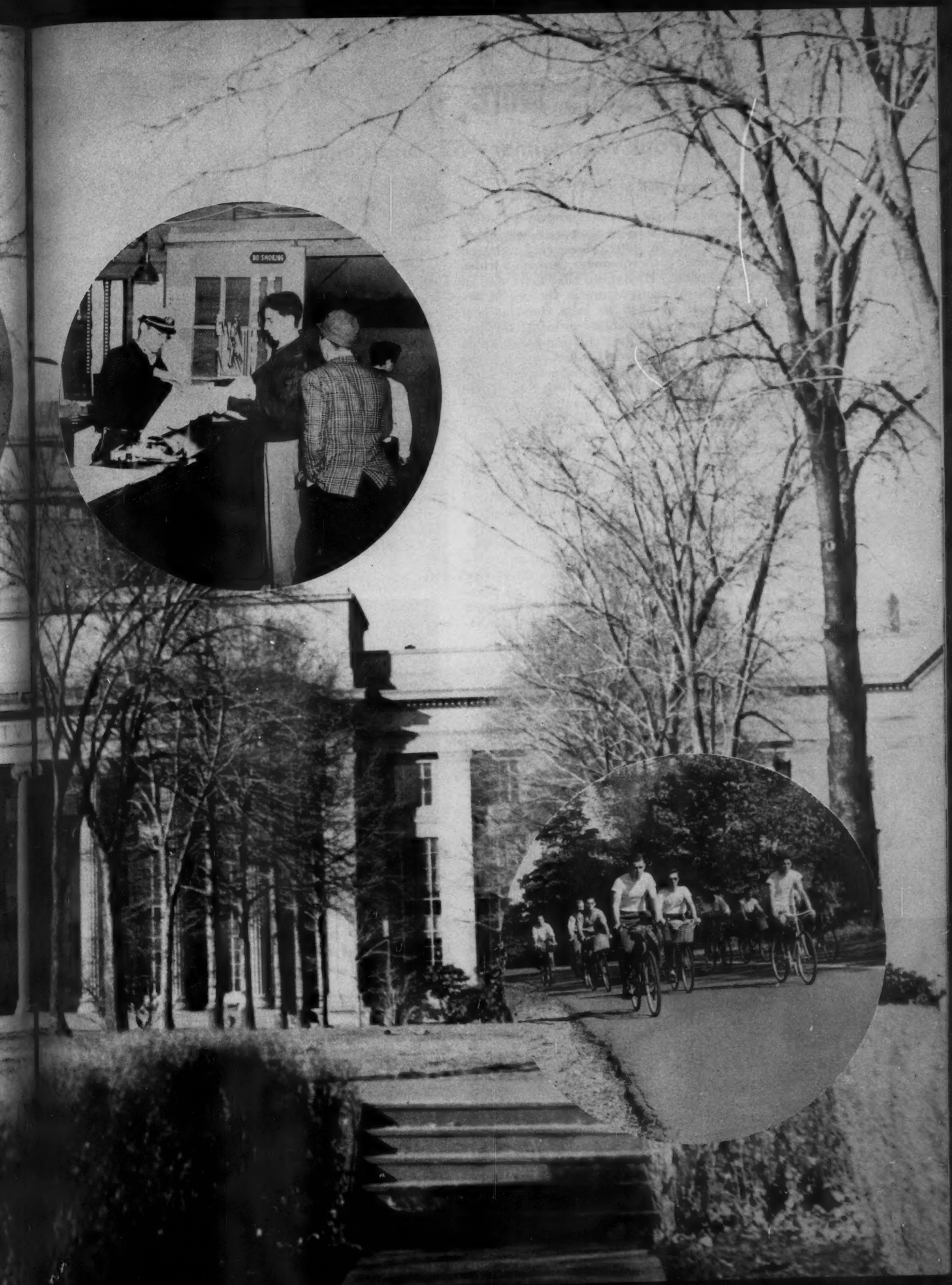


FIG. 5

NIGHT AND DAY


NO SMOKING

the camera sees more

By Paul Westheimer, '52, and Phillip Morrow, '52

From 7,000 to 13,000 Å

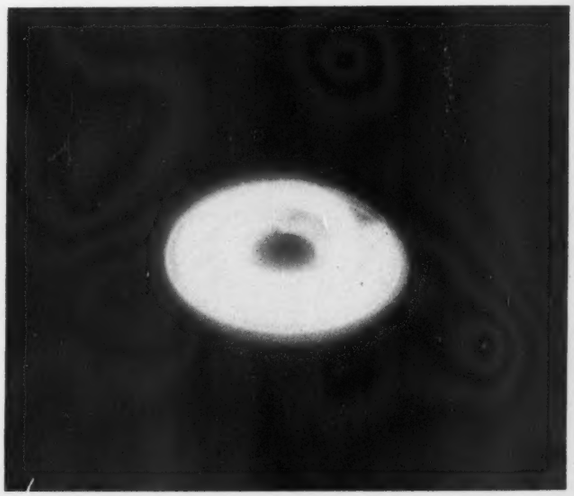
Infrared photography is by no means a new subject. Sir William Herschel, in 1800, discovered infrared radiations as he passed a thermometer through various regions of the spectrum. He noticed that there was an appreciable increase of temperature in the region beyond the visible red. In 1840 Sir John Herschel, son of Sir William, discovered the ability of infrared radiations to reverse an image on silver chloride paper. This phenomenon, called the Herschel effect, excited the curiosity of many scientists about the possibilities of infrared photography. One method which found wide application in the investigation of the infrared region of the spectrum was largely discovered by E. Becquerel. This method depends upon the fluorescent properties of certain materials when exposed to radiations of short wavelengths, such as ultraviolet light. Becquerel showed that this fluorescence is extinguished rapidly upon irradiations with infrared rays. By this method it is possible to outline images of the infrared spectrum on fluorescent materials. Becquerel claimed to have used his phosphorographic method as far out as 13,000 Å. The Angstrom unit (Å) is equal to 10^{-8} centimeters and is used in measuring wavelength. The sensitivity of the eye ranges from 4,000 to 7,000 Å. The phosphorographic method is still used in spectroscopic work for wavelengths longer than those which can be recorded on film.

The silver halide salts which are used in photographic emulsions are sensitive only to the blue part of the spectrum. However H. W. Vogel, in Germany, in 1873, discovered that it was possible to increase the color sensitivity of silver salts by using dyes. Gradually, by this method the color sensitivity of films was extended to longer wavelengths. This led first to the development of orthochromatic film which is sensitive to green as well as to blue and violet light. Later came the panchromatic films whose sensitivity closely approximates that of the human eye. Finally, with the development of dicyanine in 1904, it became possible to record wavelengths as far out as 10,000 Å.

Since these new films, however, were, and still are, sensitive to the shorter wavelengths, due to the inherent sensitivity of the halide salts, it is necessary to exclude all visible light for strictly infrared photography. This is done by the use of filters which transmit only radiations of greater wavelength than the visible part of the spectrum. For indoor photography by infrared the light source is sometimes covered instead of the camera lens. An interesting application of this procedure is the infrared flashbulb, which is an ordinary flashbulb covered with a red dye virtually opaque to visible light. These bulbs are used with infrared film for purposes such as studying audience reactions during stage or screen plays and detection of crimes.

Dicyanine, although it is a good sensitizer, had rather poor keeping qualities. Until 1926, however, this was the chief sensitizing material for infrared photography. After the first World War there followed a series of discoveries which provided kryptocyanine in 1919 and afterwards a whole series of sensitizers, most of which are of the cyanine type of organic dyes. The development of pentacarbocyanine in 1934 extended the range of emulsions to beyond 13,000 Å, the approximate limit of direct infrared photography today.

There are two methods of sensitizing photographic materials with dyes. One method consists of adding the dyes at some late stage in the preparation of the

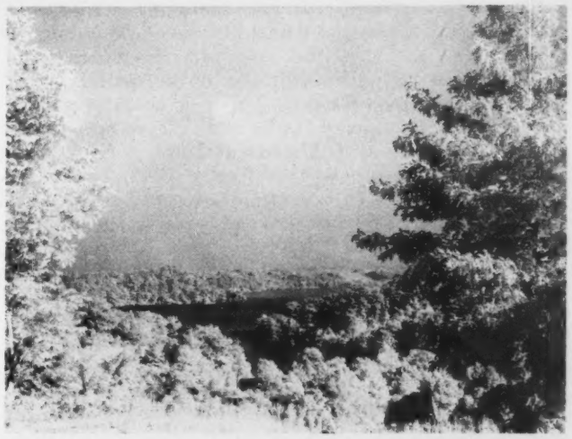


Photograph of heating unit of electric range taken with red filter on infra-red film. No light was visible to the eye through the filter.

Notice the elimination of atmospheric haze and clear definition of field boundaries in this infra-red aerial photograph.

Picture of a charred document by infrared showing fingerprints which were invisible to the eye and to ordinary film.

The top picture here was taken on non-color sensitive film and the bottom one on infrared. Notice the reduction of haze, the darkness of the water and the lightness of the foliage in the infrared photo.



emulsions, while the other consists of bathing the finished plate or film in a solution of the dye. The former method gives superior results and is that used by today's film manufacturers. For work with infrared sensitive materials where extra speed is required it is possible to hypersensitize the film just as with other silver emulsions.

The useful applications of infrared photography are many and varied. Probably the most familiar of these is haze penetration. Most haze is the result of the scattering of light, mostly blue, by moisture and dust particles in the air. Such scattering results in a hazy image on ordinary film and on the retina of the eye. Infrared rays, however, on account of their greater wavelength are scattered much less than visible light. Therefore it is often possible to have a clearer image on infrared sensitive film than is formed on ordinary film or by the human eye. However it is not possible to penetrate dense fog with infrared film since the particles of moisture in fog are much larger than those in haze and deflect even infrared rays. This haze-penetrating power of infrared films makes them very useful in aerial photography and surveying as well as for amateur and professional landscape photography. The usefulness of infrared photography to aerial photography and surveying is increased by its sharp contrast. As is shown in the illustrations, field boundaries are very clearly marked, water appears black and the horizon is sharply outlined.

Since most radiant heat is composed of infrared radiation, it is possible to study the heat distribution in parts of internal combustion engines and to study furnace interiors from infrared photographs. These applications, although very interesting, are not widely used since most heat radiations are beyond the range of infrared films.

The ability of infrared rays to penetrate certain pigments makes infrared photography an invaluable asset to the detection of forgeries in paintings, in differentiating between various textiles, in criminology and in documentary photography. In the case of paintings, it is often possible to photograph underlying sketches which are invisible to the human eye. An example of this is the well-known Rembrandt, "Herman Doumer, the Gilder." It had been suspected that this painting had been glazed or partly finished by other hands than those of Rembrandt. When this picture and a faithful copy were photographed by infrared, the copy showed no brushmarks while the photograph of the original definitely showed the characteristic brush stroke of Rembrandt. As far as textiles are concerned, it is possible to discover defects in certain darkly dyed cloths by photographing them with infrared.

This penetrates the dye and reveals the defects

(*Continued on page 200*)

industry's westward ho!

By Marc Alfandry, '50

Facts To Back Up Impressions

Up to twenty years ago, the eleven Western States, which form a third of the United States, functioned almost as a colony, widely separated from the East by distance, communications and market opportunities. For years the West has yearned for industrialization, and one may ask, "Why should the West want industries beyond those allied with its agriculture, forests, climate and cheap waterpower?" The answer is that, as a result of the century-old westward migration, the West has at present a population which can be fully employed only with the aid of nationally important industries. The map on this page shows the migration which took place in the pre-war period of 1935–40. The outbreak of war had the effect of speeding up the natural trend, with the result that since 1940 the western population increased by 18½ per cent, or more than two and one-half million, to reach an all time high of sixteen and one-half million. For the sake of comparison, the national gain of population was only 0.2 per cent.

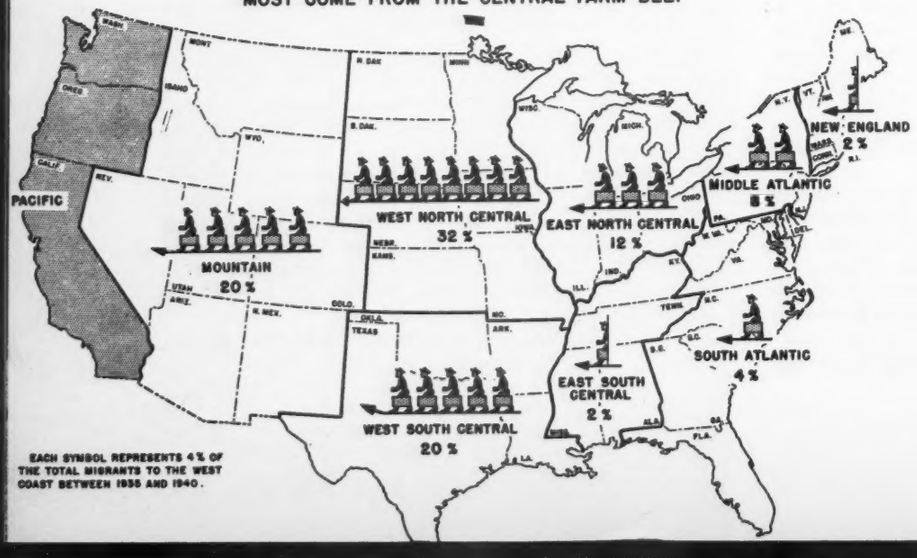
Many factors seem to be working in favor of the West's desire. The continuation of American industrialization and growth of population is bound to favor this third of the nation which has only 12.4 per cent of the total population. An even more important factor is the recognition by industrial leaders of the necessity for decentralization of industry. By decentralization is meant not only the diffusion of industrial plants within a given manufacturing area or areas, but their dispersion into scattered towns and villages outside the areas of present industrial concentration, namely away from the East. Naturally the West hopes to be favored by this trend. Decentralization has been going on for many years, although at a steadily mounting tempo. Big Business has bred Bigger Business, for the greater the fixed costs (large plant and installations), the greater the drive toward expansion in order to cover costs. Big Business was reaching the saturation point, however, because top management was unable to get its authority and power to penetrate effectively through all the layers of the huge structure under its control. The business was handicapped for lack of management at each level of operation. Furthermore, decentralization produces important social results since experience has shown that workers employed in smaller communities tend to be better citizens and be more satisfied with their work. As a result labor turnover is smaller and productivity higher.

As mentioned above, the increase in population of the Western States has been ninety-two times the national increase. It is true that this increase was greatly stimulated by the war. However, reliable studies have shown that the migration is a long-term trend and is continuing in the postwar period. This increase of the western market is bound to attract additional industrial plants. As population and per capita income have advanced at rates faster than those for the nation as a whole, there has been a corresponding increase in the demand for consumer goods. Total retail sales for 1945, for instance, were 15.6 per cent of the nation's total for a section containing 12.4 per cent of the total population; this works out to about $708 retail sales per capita against a United States rate of $565 per capita. The income per capita also compares very favorably with the national average: West — 1,341, United States — $1,150. The above data make it clear why from a population viewpoint the prospects of the West appear very attractive.

Turning now to the factor of decentralization, the indications are that American industry is well launched into a period of relocation. The fundamental factors which control the selection of an industrial site are the following: labor, raw materials, markets, transportation, and fuel or power. The West has a great deal to offer to corporations contemplating relocation or expansion.

From the standpoint of labor, the West has very efficient workers because of the high living standards prevailing in that region. Furthermore the climate is generally mild and conducive to high productivity. The labor supply situation is good because the West has characteristically been an importer of labor. Most of the newcomers come from the Central farm belt stretching from North Dakota and Minnesota in the North to Texas and Louisiana in the South. The population movements during the war followed well-

MIGRANTS TO THE WEST COAST
MOST COME FROM THE CENTRAL FARM BELT



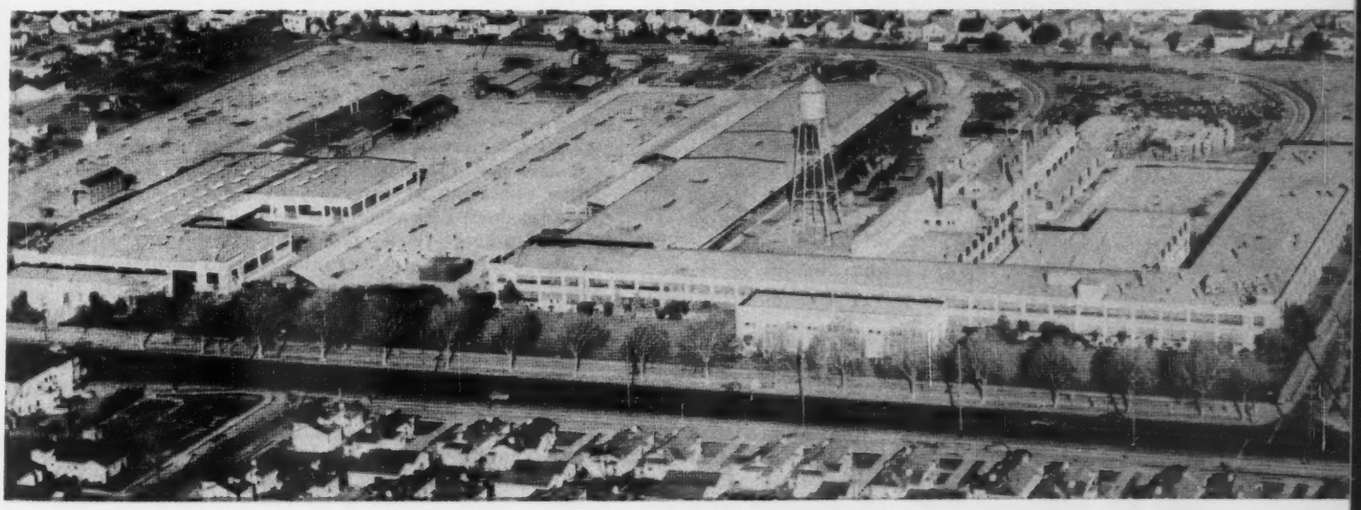
This Department of Labor chart shows the distribution of migrants to the West Coast as shown by the 1940 census.

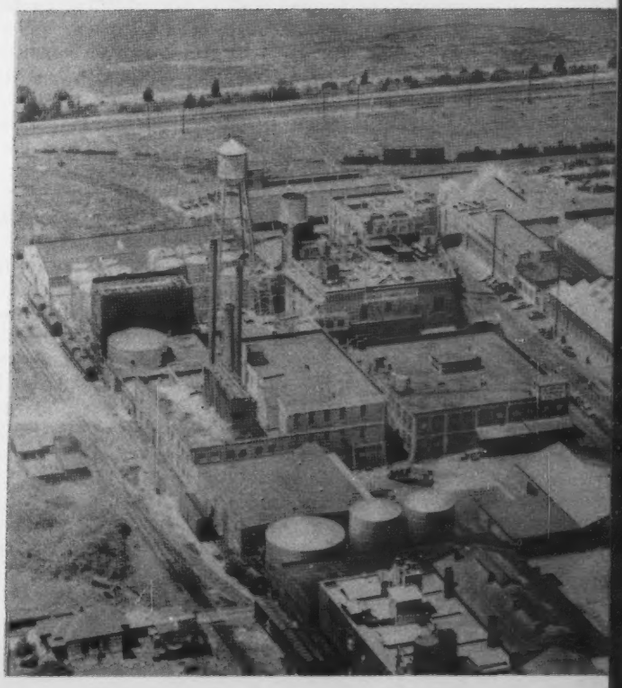
established prewar patterns; migration was from areas in which expansion of employment opportunities failed to keep up with population growth, to the growing industrial areas. The widely predicted large-scale exodus of workers from war centers in the West following the end of hostilities failed to materialize. While some return migration undoubtedly took place after the war, cities such as San Diego and Los Angeles had considerably larger populations early in 1946 than in April, 1944. This is attributable not only to the return of servicemen, but also to the fact that the economy of the West was very successful in absorbing workers displaced by reconversion cut-backs in war production. Within a year after the war's end, the number of employees in nonagricultural establishments had reached the V-J day level. This relatively smooth transition from war to peacetime activities has encouraged workers who migrated during the war to remain in the West.

The West is blessed with a great variety of natural resources, and has the greatest variety of commercial mineral resources of any comparable area on the face of the earth. Many of the deposits of mineral resources are vast in extent; some of them being practically inexhaustible. Some of the minerals found there are not found elsewhere in the world: copper, lead, zinc, mercury, borax, asphalt, petroleum, natural gas, sulphur and others too numerous to list. Texas City has the only tin-processing plant in the Western Hemisphere. Under construction are plants for manufacturing starch and dextrose sugar from the new grain, milo maize, which can be harvested with a combine.

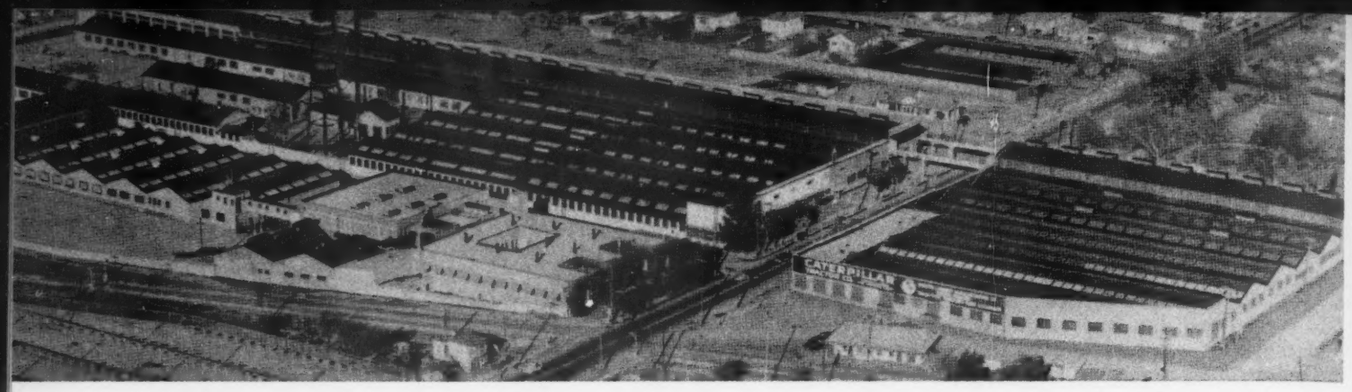
Untapped and growing markets exist in the new regions of the West. For example, the Pacific Coast leads the nation by 34 per cent in retail sales increase during the period 1939–1945. Statistics show that one hundred Western States consumers buy as much as one hundred twenty-five Easterners. The "Quality of Market" index — which is a weighted index for sales quotas divided by Per Cent of USA population — shows that the West leads every other region with a figure of one hundred eighteen against a United States figure of one hundred. Also the location of the West near the tremendous potential demand of the Asiatic peoples is another factor which points to a future that seems unlimited.

Transportation conditions are very favorable. Expansion of the existing highly-developed transportation facilities during the war makes the West the hub of a complex network of railways and highways. Moreover, in May 1945, the Interstate Commerce Commission ordered a 10 per cent reduction in Western railroad freight rates for manufactured articles, and a





Among the growing number of industrial plants appearing in the West are: above, Chevrolet-Oakland Division of General Motors, and right, Durkee Famous Foods.



The Caterpillar Tractor Company has also seen fit to erect a plant on the West Coast, this one at San Leandro.

10 per cent increase for the same freight within the Northeast. The implication suggested is that the Commission considers the industry and manufacturing of this country spread out to a point where preferential rates for the heavy traffic of the Northeast should be modified in favor of the growing traffic in the West and South.

As already stated above, the West has abundant resources of petroleum and natural gas; furthermore, large hydroelectric stations provide electric power. For instance, in the Metropolitan Oakland Area in California, industrial lighting and power can be had at the following rates:

Demand	*Monthly Delivery*	*Average Cost per KW Hour*
1000 kilowatt	400,000 KWH	$0.0085
	200,000 KWH	.0110
300 kilowatt	120,000 KWH	.0094
	60,000 KWH	.0124
75 kilowatt	30,000 KWH	.0117
	15,000 KWH	.0156

The part played by the West during the war has been outstanding. One of the most intriguing and perhaps the largest war plants in the region was the plant at Richland, Washington, which played so vital a role in the production of atom bombs. Operation of this plant was taken over by a large electric company. For 1947 and subsequent years, the program proposed, "under the sponsorship of the Manhattan Division of the United States Corps of Engineers, will consist of two parts. One will be fundamental research and the other construction and development." Employment at this plant has been around six thousand.

Other wartime developments worthy of mention lie in the chemical field. At Portland, Ore., two calcium carbide plants were built, with a third at Tacoma, Wash. A modern coke plant was erected at Tacoma using coal from local mines. Two companies have chlorine and caustic soda plants at Tacoma; one of the companies also operates a sodium and potassium unit at Portland.

Shipbuilding and aircraft production, small industries before the war, sprang into the limelight and quickly became the largest employers of manpower in the region. More fundamentally significant, if less spectacular, developments occurred in minerals and metals, especially the electrometallurgical industries, attracted by the abundance of cheap hydroelectric power. Ferrosilicon plants were built at Wenatchee and Spokane, Wash., a ferroalloy plant was operated at Portland, Ore., and a ferrochromium plant was constructed at Tacoma, Wash. Electrolytic manganese was produced at Hoodsport, Wash. Electrolytic copper was and still is refined at Great Falls, Mont., and at Tacoma, Wash. Electrolytic zinc was and continues to be produced at Kellogg, Idaho, and at Anaconda and Great Falls, Mont.

Although some steel is being produced in the region, outstanding progress has been made particularly in the production of light metals, particularly aluminum. The new industry was initiated by the establishment of two plants by private companies, one at Vancouver, Wash., in 1940, and the other at Longview, Wash., shortly after. As the war demands became pressing, three additional aluminum reduction plants were constructed by Defense Plant Corporation. These five plants, when operating at capacity toward the end of 1943, were producing at an annual rate of nearly six hundred million pounds, well over twice the prewar capacity of the United States. In addition to these reduction plants, a large, modern aluminum sheet rolling mill, with capacity of some twenty million pounds monthly, was built by DPC near Spokane, Wash. The light metals industry is also represented in the region by a magnesium plant located near Spokane, Wash. Using dolomite ore from north of Spokane and ferrosilicon made on the site, the plant has an annual capacity of forty-eight million pounds of magnesium. In view of the cost-price relationship it had been thought that this plant would have little prospect for postwar operations. However, when the plant was placed on sale by the War Assets Administration, in January 1947, two substantial bids were made for it.

As the foregoing facts indicate, the future of the West should be bright. Existing evidence suggests that the region will continue to expand at a rate somewhat above that of the 1930–40 decade. The outlook for specific industries is also on the whole encouraging. This is particularly true of aircraft and shipbuilding. Uncertainties as to the future of the aluminum industry have now yielded to optimistic hopes. The Vancouver, Wash., plant is operating at capacity and the company is working on plans for a local source of alumina, possibly using Oregon ores.

Summing up, the economic outlook for the region is good, assuming no serious national recession. Population growth is expected to continue, with employment opportunities keeping pace. Unemployment is not expected to rise greatly. In fact, labor shortages, which have held back certain industries, notably construction and building, are likely to continue. Incomes will probably remain high on a per capita basis, assuring a better than average as well as a growing market within the region.

spanning the mystic

By Roy W. Jenkins, '50

New $27,000,000 High-Level Bridge Will Eliminate Traffic Bottleneck

Boston is old and, as a result, reluctant to change, to progress. It has been said the first streets in the city were laid out from the devious paths followed by homebound cattle from the common pasture land. In whatever manner the streets of Boston were laid out, modern traffic, from the Metropolitan area as well as from the through highways, has found the highway system of Metropolitan Boston a constant source of vexation, tieups, and accidents. Being instinctively resistant to change, the highway development of the area has lagged twenty years behind most of the other great metropolises of the country.

But at last, upon being threatened with virtual economic strangulation or suicide, the people of Boston and the Commonwealth have awakened to the necessity of a few vital changes, of some rapid progress in the direction of transportation. An enthusiastic, ambitious Master Plan of Highway Development has been conceived, and the State Legislature has voted funds for specific designs to be drawn. The first project of this three hundred fifty-six million dollar program is the Mystic River Bridge, the construction of which is well on the way towards its projected completion sometime in 1950.

And one might well ask, what and where is the Mystic River? Emptying into Boston Harbor just north of the Charlestown Navy Yard, the river is navigable to ocean-going vessels for only about a mile of its length. But that mile is lined on both sides with coal storage yards, oil depots, freight terminals, coke works, a sugar refinery, a large iron works, and other heavy industries. As a matter of fact, twenty-five per cent of all Boston water tonnage goes into this veritable beehive of industry.

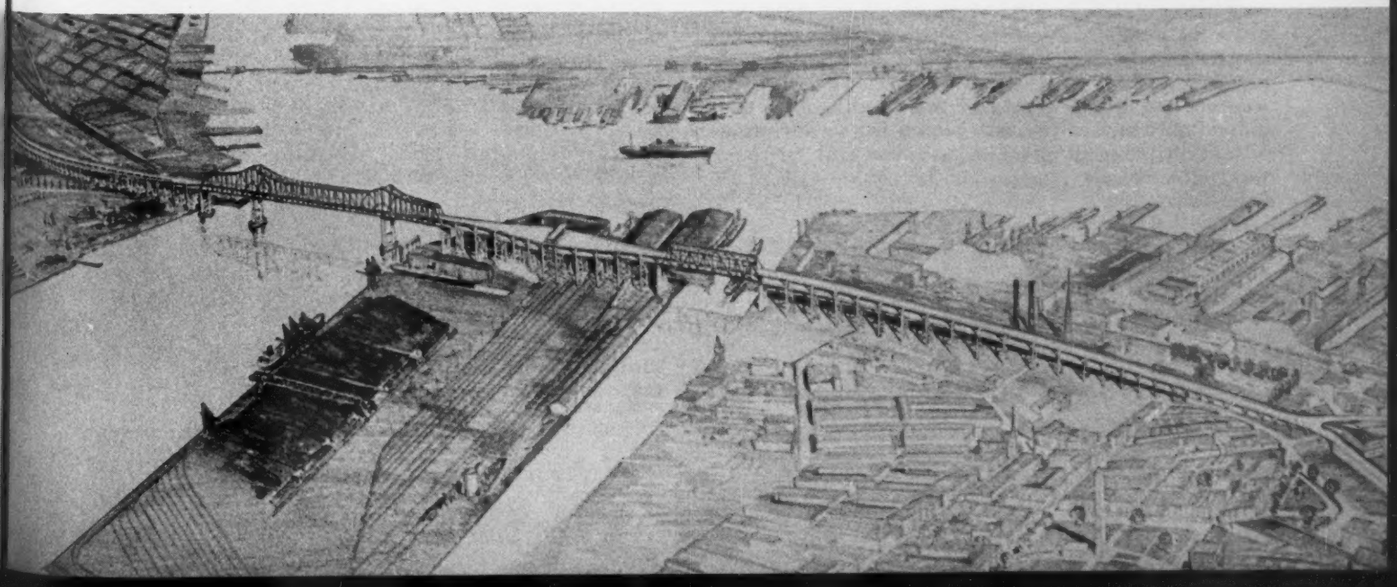
What is believed to have been the first ferry in America crossed the mouth of the Mystic River in 1633. At present, the crossing from Charlestown to Chelsea is an antiquated, low-level, swing-draw bridge which has constantly been one of Metropolitan Boston's worst traffic bottlenecks. The drawbridge opens more than seven thousand times a year with repeated, rush-hour openings causing tieups as far back as five miles on each side of the river.

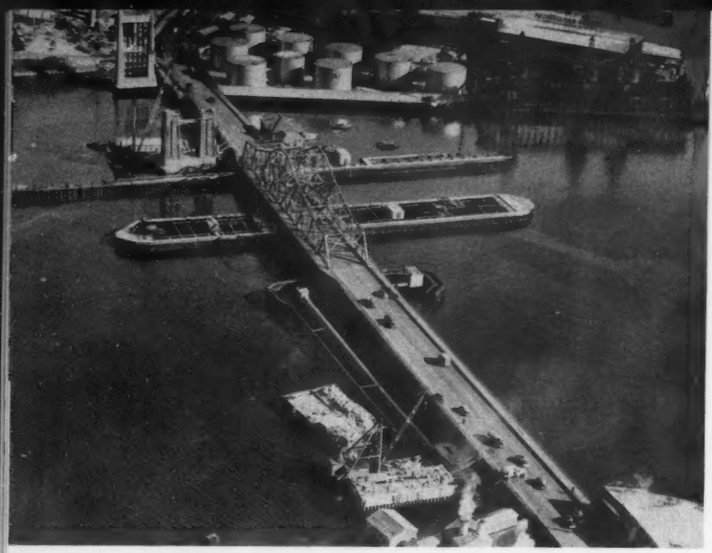
The new bridge will solve almost all of the inherent difficulties presented by the old. With its strategic approaches and direct connections with U. S. Route 1, arterial traffic will be able to bypass several business centers and eliminate all contact with local traffic. As a structure the Mystic River Bridge will be the equal of any of the great bridges of the country. It will be a high-level, double-decked structure measuring 11,900 feet from grade to grade. Unlike similar two-level bridges, there will be no separation of the traffic, diverting trucks and busses to one level and passenger cars to the other. Instead, all the traffic going south will use the upper level, all the traffic heading north, the lower; this arrangement eliminates any possible head-on collisions on the bridge itself.

The substructure consists of twenty-one full-height, stabilizing concrete piers, interspersed with numerous steel bents supported on ground-level foundations. The most spectacular part of the substructure is the deep-water piers in the Mystic River. The two main piers will support the center span, eight hundred feet long, as well as two cantilever trusses of three hundred sixty-two feet each. These structures represent a lot of steel and a tremendous weight to be concentrated in a relatively small area.

The deep-water piers are being constructed by Merritt-Chapman and Scott Corporation, a firm that has constantly met the challenge of the unusual and the difficult in waterfront construction. Looking at the overall picture of this job, the contract called for the construction of three all-concrete piers from bedrock to an elevation of one hundred thirty-seven feet above low water in the case of the two main piers and slightly less for the third pier. The existing swing-drawbridge is located only twenty-eight feet from the new piers, and its proximity presented several additional problems as well as solving several others. But that is getting ahead of the story. First let us examine, step by step, the processes and problems involved in the construction of the largest of the two main piers.

When completed, pier M-2 will have an overall height of two hundred sixteen feet, from rock foundation to top elevation, contain over ten thousand cubic





Aerial photograph taken February 3.

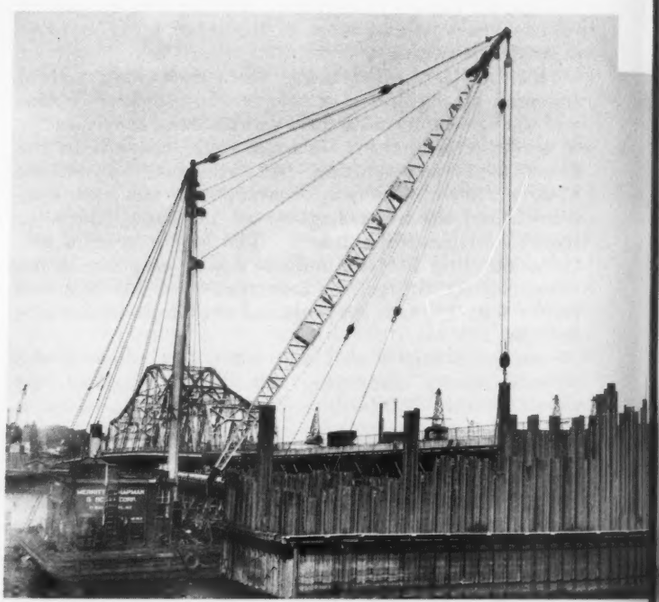
The floating derrick "Cincinnati" driving sheet piling for the M-2 cofferdam.

yards of concrete, and be perhaps the largest all-concrete pier in the country. Preliminary borings had shown bedrock to be about eighty-five feet below mean low water, and, as a result, the designing engineers had decided to rest the deep-water piers on this rock instead of relying on the steel H-sections used under the land piers. This decision meant that sixty-six feet of overburden had to be excavated before the base slab could be cast.

The primary excavation, stripping about sixty feet of the clay and sand, was accomplished by a twelve cubic yard electric dipper dredge with a ninety-foot dipper arm. This excavation was in the form of a shallow bowl whose bottom was the effective area of the cofferdam to be erected. Previous to this, however, the contractors foresaw the danger of undermining the wood pile foundations of the existing bridge and the aqueduct which runs parallel to the bridge. Steel H-sections were driven to rock on both sides of the aqueduct and like sections were used for caps and stringers, thus creating a stable platform with no danger of undermining. Between the old bridge and the aqueduct, a line of sheet piling was driven into the hardpan layer surmounting the rock. This bulkhead was tied back to battered, timber-pile "A" frames which had been driven on the downstream side of the old bridge, by means of two-inch diameter tie rods, six feet apart.

And now, with the existing bridge effectively buttressed against collapse or movement, and the primary excavation completed, work was begun on the cofferdam itself. First, heavy timber falsework was set up on steel H-section piles as a template and guide for the sheet piling. The sheet piling required to reach bedrock necessitated lengths of up to ninety-eight feet. Since the longest sections rolled are seventy-eight feet, shorter lengths were welded together on the job to the required length. As the individual, full-length sheets were set and driven, great care was taken to keep them individually and collectively plumb in two directions. The extensive precautions to maintain a plumb structure were necessary to insure the correct size of the base slab.

After each and every sheet had been driven to refusal, denoting contact with the bedrock, the secondary phase of excavation was begun. The secondary excavation was carried out in two steps. Much of the remaining overburden on the rock was first removed by a crane-powered clamshell bucket, a slow and tedious process in eighty to ninety feet of water. However, before further excavation could proceed, it was



necessary to install the cofferdam bracing, a structure of one hundred sixty-seven tons of steel.

The cofferdam bracing was composed of five frames. Each of these frames consisted of a perimeter wale with cross shoring and knee-braces. The heaviest of these had a double twenty-four inch, one hundred twenty pound, wide flange section for wales and fourteen inch, one hundred three pound sections for shores. The bottom frame was set up and bolted together at the top of the cofferdam, and temporarily held there by bolts through the sheeting. On the completed bottom structure, timber and light H-section posts were set up, and the second frame was asembled on top of these posts. Tie rods and vertical cross bracing between the two frames completed the connection. The two frames, now one structurally sound unit, were lowered to their final elevation at the bottom of the cofferdam and held there by wire rope straps secured to the top of the sheet piling. The total weight of these two frames was about eighty-one tons, consequently two large floating derricks were required to lower it into place. With the bottom unit of the bracing in place, the top section of three frames was assembled, lowered into place, and held there in a manner similar to the bottom section.

And now the third and final excavation was continued. The remaining material to be excavated was a hard packed mass of clay and gravel, piled up in the corners of the cofferdam, against the sheeting, and distributed over the bottom, all inaccessible to a clamshell bucket or any of the other usual means of excavation. And so, an unusual, job-built rig was used. It consisted of a vertical twelve inch steel pipe about ninety-five feet long with a twenty foot horizontal piece welded on the top. Fastened to the outside of the vertical pipe and turned up six inches inside at the bottom, was another one inch pipe, the whole rig being held up by a barge-mounted crane. The process was this: air at one hundred pounds pressure was fed into the one inch pipe from two large compressors on the deck of the barge. This air pressure, transmitted to the bottom of the large pipe, held about a foot off the bottom, created a suction, and, in effect, cleaned the material off the rock like a large vacuum cleaner. But, in order to remove all of the overburden from the rock, it was necessary that the hard-packed mass be agitated.

To accomplish this underwater agitation, it was necessary to use deep-sea divers. A high speed, jet pump was set up on the barge and supplied water through a two inch jet pipe (also supported by the crane). A three-quarter inch nozzle was attached to the end of the water pipe, and the diver directed the powerful stream at the hard-packed mass below the lift pipe, loosening and softening it up enough to allow it to pass up through the pipe and be deposited on the outside of the cofferdam.

Because of the excessive depth at which he was working, the diver could stay down only an hour and a half. On coming to the surface, he spent an hour and a half in a decompression chamber and another hour and a half resting. By using two divers on each shift, operations were carried on continuously.

After several weeks of round-the-clock operations, the rock bottom was declared completely clean and thus in readiness for the base slab.

The base slab of concrete varied in thickness from forty-five feet to a minimum of thirty-five feet and had to be poured continuously until completed. It was a tremendous undertaking, pouring four thousand thirty-eight cubic yards of concrete under eighty-five feet of water. The process of pouring concrete under water is known as the tremie process and is accomplished by chuting the concrete down a twelve inch pipe, the bottom of which is constantly kept immersed in the concrete previously poured. The pipe is held in one position and the plasticity of the concrete allows it to flow over a large area.

By judicious planning and location of three of these pipes, ninety-five per cent of the slab was poured without movement from their original positions. Leveling off was accomplished by moving the pipes to those positions which soundings showed to be deficient in elevation. Each of these pipes was surmounted by a small hopper and platform, and the whole rig was supported by a floating derrick. By vertical movement of the tremie chute, the concrete was kept flowing and the only contact with the water was the top layer of the concrete already poured. This contact resulted in the formation of a six-inch layer of laitence, which was later cleaned off.

The tremie pour was the first operation which allowed the old, existing bridge to be placed on the asset side of the ledger. Its proximity this time was a distinct advantage. Transmit-mix concrete was chuted from the trucks on the bridge in three locations. One thirty-five foot chute fed one hopper. Two other shorter chutes supplied two Pumpcrete machines which, by means of pistons, driven by eccentric shafts, forced the concrete through an eight inch pipe. From each machine, the pipe extended over an elevated platform, and, passing through an end section of heavy rubber hose, deposited concrete into each of the other two hoppers.

Eighty-six tons of cofferdam bracing is lowered into place.

The disposal end of the air lift or "vacuum cleaner."

The four thousand thirty-eight cubic yards was poured in only thirty-three hours, mainly because of adequate organization and planning, but also because of a minimum of breakdowns and unavoidable tieups.

A week later, pumps were set up on two levels and the cofferdam pumped out, thus permitting work on the substructure to continue "in the dry." Because the interlocking joints between the individual sheets of the bulkhead allowed some water to seep through, it was necessary periodically to pump the "dam" dry. The seepage was cut down considerably by throwing a mixture of sand and fine cinders on the surface of the water outside of the bulkhead over a troublesome leak. The sand and cinders would be sucked down into the seam and plug it sufficiently to cut the leak down to a minimum.

With the cofferdam pumped out and the top of base slab exposed, the six inch layer of laitence was removed by hand-loaded skips. Forms were set up two feet inside of the sheeting and a ten foot distribution block was poured. The next pour, over twenty-five hundred cubic yards, brought the concrete up to an elevation of about eight feet below mean low water.

With the top of the concrete as a base, the first course of the granite facing of the pier was started. It is necessary to use granite facing on that portion of a concrete pier which is alternately exposed to water and air. While neither of these substances is destructive to concrete when acting alone, the two, combined with the consequential freezing and thawing, heating and cooling, have a marked destroying effect, particularly in the case of salt water, and salt-laden air. Thus, as in the case at hand, it is standard practice to use granite on the exterior of bridge piers between the high and low tide marks.

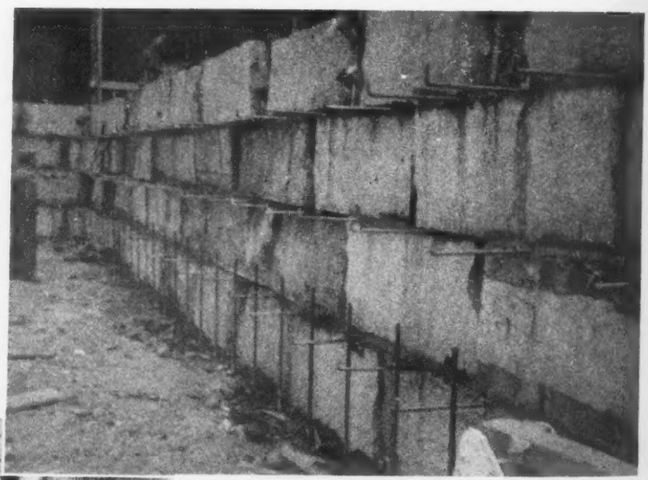
Ten courses of Chelmsford granite blocks, approximately two feet square in cross section and up to ten feet long, were used on the exterior of all the deep-water piers. The blocks were anchored to the concrete with one inch round, galvanized anchors. To eliminate unnecessary staging and provide a good working platform, the concrete within the outer ring of granite was poured after every fourth course.

With all the granite in place and the pier construction above high water, the pumps were removed and the cofferdam flooded. Previously, however, provision had been made to remove as much of the bracing as feasible. The individual wales had been cut free from the shores and other wales, and each fastened to the top of the sheeting by means of wire rope straps.

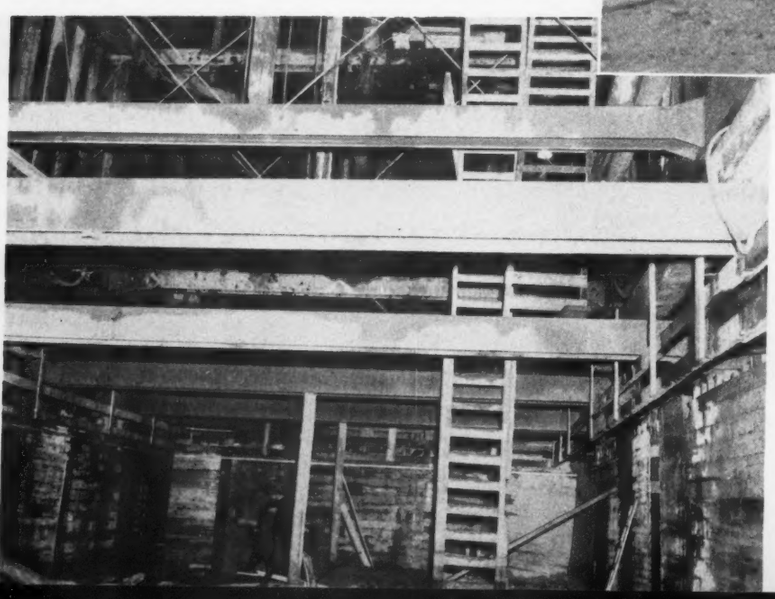
However, before proceeding further with the dismantling of the cofferdam structure, the eight foot thick base for the pedestals was poured. The forms had been set on the top course of granite, braced to the top of the sheeting, and tied together with Richmond ties.

The first step in the dismantling of the cofferdam was the removal of the bracing, the individual members of which were simply hoisted out on end. With all the bracing removed, the sheet piling will be pulled out individually. From the experience with the cofferdam for the other main pier, the construction of which is about a month ahead of that on pier M-2, it appears that some of the sheet piling will be rather difficult to pull. The extraction of sheet piling is accomplished by the use of a steam-driven extractor which is simply a steam hammer working in reverse, that is, driving up instead of down. In the case of the sheets on M-3, an eighty ton strain was exerted on a single sheet after it had been loosened by the extractor. But the eighty ton lift was still insufficient to move the sheet which had probably either penetrated into the rock or rolled up in such a manner as to make removal impossible. The few sheets that could not be removed were cut off at the river bottom by a diver. Incidentally, the sheet piling that is removed is about ninety-five per cent salvable and will be used on some future job.

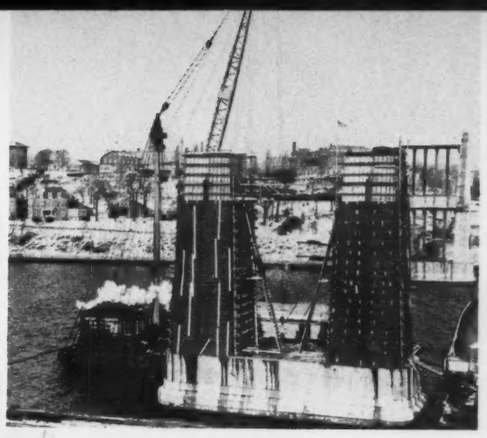
To get back to the actual pier construction, the remaining work is now above water and consists of erecting the forms for the pedestals and beams. The pedestal forms are put up in two fifty-seven foot high sections. The panels are made up of three by six studs with inch and a quarter sheathing, faced with quarter inch plywood for a smooth finish. Before the panels are erected, all of the double, three by six wales are fastened in place, and a twelve inch, fifty-three pound



The first four courses of granite. Note the anchors that will be embedded in the concrete.

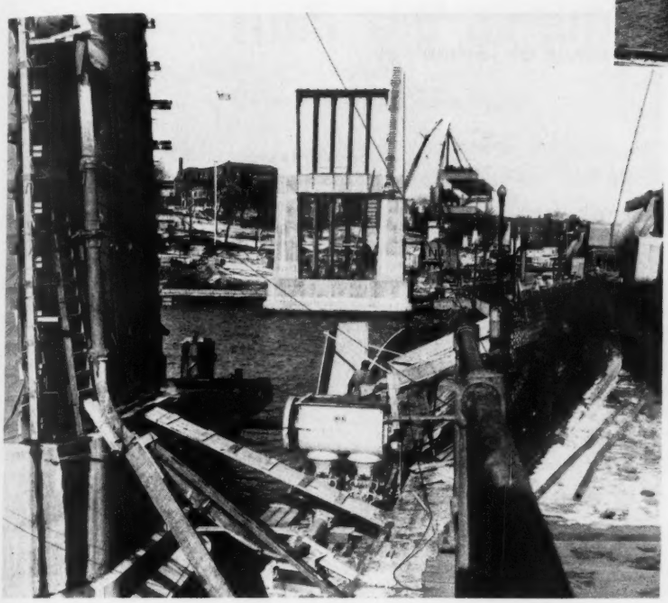


The cofferdam pumped out and the forms for the distribution block erected.



The pedestal forms ready for concrete, with the "Cinci" standing by.

Closeup of the Pumpcreting operation.



H-section bolted vertically over these wales to act as a stiffener and to allow the panels to be stripped without damage. Since the pedestals and beams for the two main piers are identical in size, the one set of forms that was built will be sufficient for the two piers.

The lower section of the pedestal forms will be set up first, four panels for each one. Six by six corner posts tied together with long bolts will hold each pedestal form secure in itself. In order to maintain the structure at its seven-sixteenths inches per foot batter on each face, two half inch wire rope guys will be fastened near the top of each panel and secured to anchor bolts in the concrete base. Temporary twelve by twelve spreaders between the two forms will also act as a working platform. With the forms in place, the carpenters will proceed to install the form ties, slightly hampered by the iron-workers who will be setting and tieing the reinforcing steel in place. With the ties all tightened and the forty-odd tons of reinforcing steel set in each pedestal, the concrete will be pumped to the top of the forms by the Pumpcrete machine and poured into place through "elephant trunk" chutes.

With the pedestals poured to the bottom of the lower beam, the falsework for the support of the beam forms will be erected. Twelve by twelve posts set on oak wedges and topped by twelve by twelve caps will support the twelve-inch, H-section stringers. On these stringers, the beam bottom forms will be set, the beam sides erected; and more ties and tons of reinforcing steel will be put in place. The second pour will be the depth of the beam and the full width of the pier.

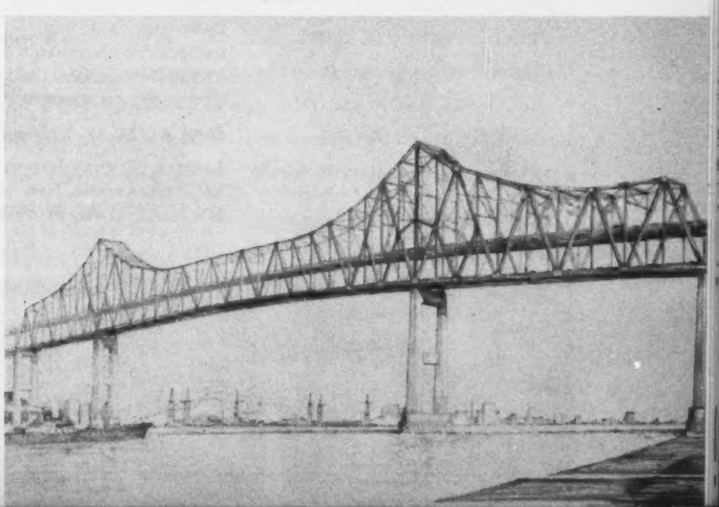
The erection of the top section of the forms is a job that will utilize the full capacity of the floating derrick "Cincinnati." With its one hundred thirty-five foot boom topped by an eighteen-foot jib, the "Cinci" is a useful rig, and on the construction of these piers has performed many difficult tasks comparatively easily. With few minor differences, the forms for the upper section of the pedestals and the top beam will be erected and secured in the same manner as the lower section.

Present plans call for most of the remaining concrete to be placed by Pumpcreting. The eight-inch pipe will be secured to the concrete previously poured, and the new concrete will be pumped up and into place. If, however, this process proves unsuccessful, or an unavoidable breakdown occurs, it will be necessary to utilize the ever-present "Cincinnati" to hoist the concrete into place by means of a one-yard bucket — a slow and tedious process.

Contrary to usual practice, most of the concrete for the two main piers has been, and will be poured from December to March. Before a pour is made, the forms are completely enclosed in tarpaulins underneath which perforated pipes circulate steam. The steam is supplied from one of the derricks and is turned on soon after the pouring operation has started. For seven days and nights, the temperature of the fresh concrete is kept above a minimum of fifty degrees, thus insuring structurally sound concrete despite the freezing temperature outside.

The deep water piers will be completed sometime in April. The erection of the steel trusses and the roadways will require at least another year. It is hoped and expected that the new bridge will be opened for traffic sometime in 1950. The old bridge will be demolished, the channel widened and deepened.

With the new bridge opened, the graduated scale of tolls (starting at ten cents for passenger cars) will start money rolling in and this money will gradually accumulate. Present plans call for the twenty-seven million dollar bond issue to be completely paid off by 1978. In that year, the Commonwealth of Massachusetts will take over the bridge from the Bridge Authority, and the tolls will be suspended.



the tech engineering news

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from the editor's notebook

Defeatism from Two Sides . . .

There has been some criticism raised about a defeatist attitude taken by college students concerning world affairs. That such an attitude exists, we agree — we have noticed it on our own campus. However, the picture may not be as black as it is painted. That there *are* students at college is a fact which seems to indicate that, in spite of attitudes, people are planning for the future.

There are at least three ways of looking at this phenomenon. Those at school may fully expect that there will be a future worth working for, as they are doing, in which case the manifest pessimism is only noise. Or again, some may assume that there is a one-in-one-hundred chance of such a future and are banking on these long odds. Social pressure may be the third cause of the fact that there are college students in the face of what may be no future. A fourth reason might lie in the inertia of the social system and its component beings, although such an excuse sounds weak.

It seems to us that college students, in spite of their fears, believe in one of the first two reasons and are not going to lay down their slide rules and let the future, or lack of it, come as it will without their having tried to do something about it.

Apropos nothing that has gone before —

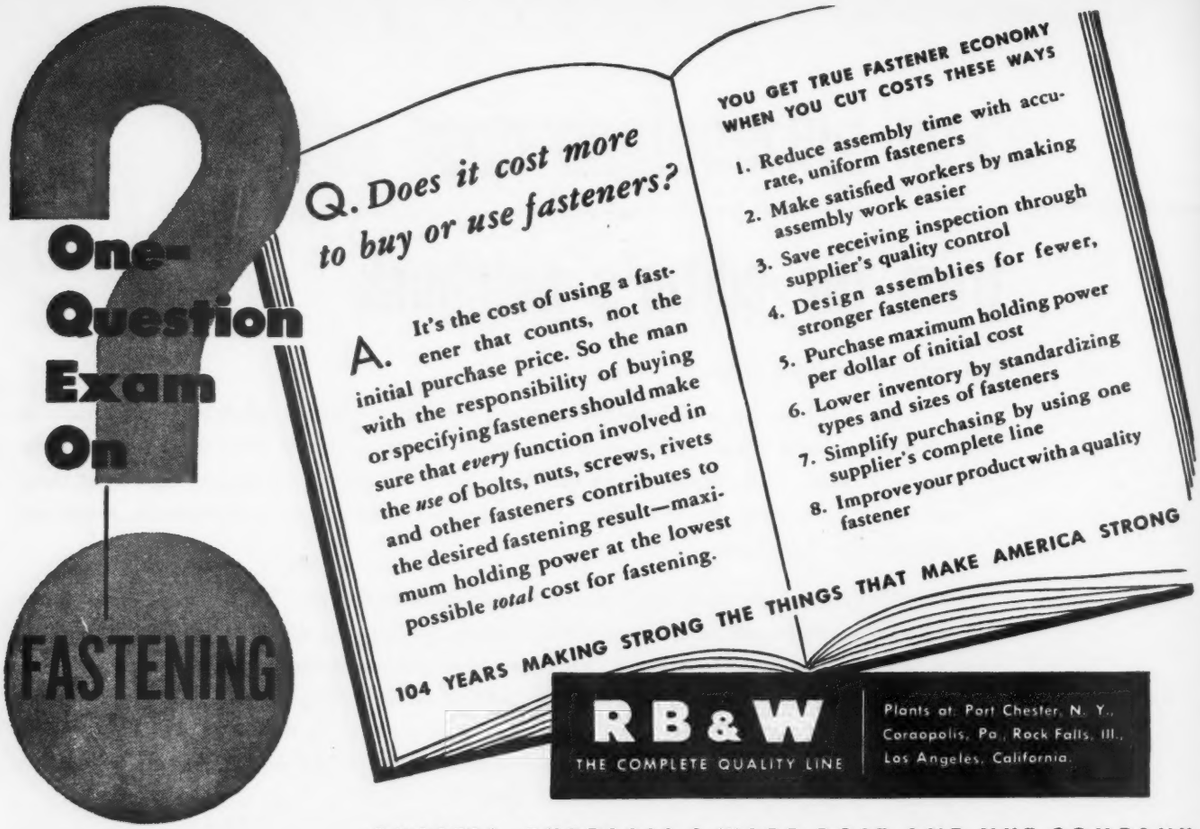
After reading the introduction to "Cybernetics" we were feeling rather low about the future of the human brain, but a recent bit of news in *Time* made us a little happier. A neurologist has reported that an electronic brain with one-thousandth as many tubes as the brain has neurons, would require the Niagara Falls to power it and the Niagara River to cool it. Inefficient in some ways, perhaps, the brain seems to be here for a while yet.

K. K.

The New and the Old

Some of the best ideas we get in the way of articles come from freshmen who have just begun to write for *T.E.N.* One of these ideas is the article on Professor Wiener which appears in this issue. **Milo Backus**, its author, seems to have one of the best high school records with which a freshman could come to Tech. Recipient of a William Barton Rogers scholarship here, Milo expects to enter Course VIII. He hails from Riverdale, Illinois. Another article written by a freshman author, or rather a couple of them, is "The Camera Sees More," by **Paul Westheimer** and **Phil Morrow.** Paul, who arrived in the U.S.A. from Switzerland in 1941, and Phil, who has traveled widely here as the son of an Air Force officer, are both camera enthusiasts; the former is a steady photo contributor to *T.E.N.*, while the latter boasts an ardent interest in the Outing Club.

Roy Jenkins, '50 ("Spanning the Mystic"), **MarcA lfandry**, '50 ("Industry's Westward Ho"), and **Alex Bloch**, '50 ("Hot Air Goes to Work"), are all familiar to *T.E. N.* readers as authors of long standing.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wiener—paul bunyan of m. i. t.

(*Continued from page 171*)

trouble with one of the problems. He asked Dr. Wiener to explain it. The Doctor read the problem, looked thoughtfully at the class, and mumbled a few numbers to himself. He then turned around and wrote on the blackboard, '622.' Having learned nothing, the student again raised his hand and told Dr. Wiener that he still didn't quite understand. The Doctor said, 'Well, we'll do it another way,' and erased the '622' from the board. He looked at the class and mumbled to himself a little while longer. He wrote '622' on the board again, and turned to the class with a triumphant smile. 'There, you see — we get the same answer this way.'"

Dr. Wiener felt great sympathy for the plight of his colleagues in totalitarian Europe before the war and in war-ravaged countries after it. He has been responsible for helping at least fifteen of these unfortunate men to enter the United States and obtain teaching positions in American colleges and universities. He and his wife frequently send food parcels to friends and relatives in Europe.

Dr. Wiener's concern for the welfare of the race is revealed in his famous letter of 1947 to an aircraft company that had asked for information on his war research. The letter, later published in the *Atlantic Monthly* and several anthologies, states many of his views on the place of science and the scientist in a troubled world. Entitled "A Scientist Rebels," the letter states in part:

"The policy of the Government . . . during and after the war, say in the bombing of Hiroshima and

(*Continued on page 192*)

BURIED ALIVE

Aerial cable gets protective wrapping before going underground.

A highway near Ann Arbor, Michigan, was being widened. This meant that a telephone pole line had to come down. But the cables it carried were too busy and too important to be cut. They had to remain in constant use.

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DU PONT Digest
For Students of Science and Engineering

PRODUCING METALLIC TITANIUM FOR INDUSTRIAL EVALUATION

Du Pont group research developed a pilot plant with daily capacity of 100 pounds

Du Pont research has just made available to industry what may become one of America's key structural materials, titanium metal. Midway in density between aluminum and iron and with an especially high melting point, silvery-white titanium offers an extraordinary combination of strength, lightness, corrosion resistance and hardness.

Titanium is the ninth most common element. But it has been slow in coming into its own as a metal because of the difficulty of separating it in pure form from its ores.

Men pictured *on this page were members of titanium research team. E. L. Anderson, A.B.Ch., Brigham Young '40; J. B. Sutton, Ph.D.Phys.Ch., West Virginia '35; A. R. Conklin, M.S.Phys.Ch., Georgia '40, are shown inspecting 300 lbs. of Du Pont titanium metal sponge.*

Du Pont scientists first began to probe the possibilities of metallic titanium in the course of their long experience with the titanium oxide pigments. Their research was interrupted by World War II. Meanwhile, the U.S. Bureau of Mines laboratories succeeded in producing the metal for research purposes.

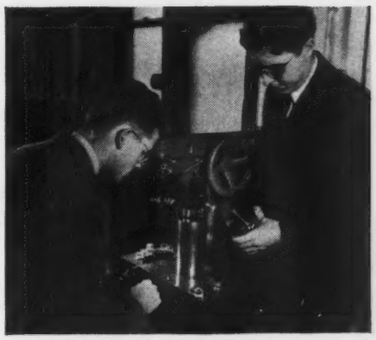
After the war, Du Pont scientists developed a process for the production of ductile titanium metal that can be scaled up to meet commercial demands. The research team that mastered the complex problem consisted of chemical engineers specializing in design and production, as well as chemists and a metallurgist. In September 1948, a pilot plant was opened with a daily capacity of 100 pounds. Titanium metal is now being produced in sponge and ingot form. Samples are available to industrial and college laboratories with research projects in related fields. Studies of methods for forming, machining and alloying are under way.

Exhaustive studies will be necessary before the many possibilities of titanium metal can be known. Because of its high ratio of strength to weight, early uses may be in airplane power plants and structural parts. Its hardness and rust-resistance recommend it for railroad transportation equipment, marine power plants and propellers, and food packaging equipment. Its high melting point suggests use in pistons, and its resistance to electric currents points to electronics. Titanium wire may be used for springs and titanium sheet for such highly stressed parts as microphone diaphragms.

Your Opportunity in Research

The commercial development of titanium metal is a typical example of Du Pont research in action. However, the Pigments Department, which worked out the process, is but one of the ten Du Pont manufacturing departments. Each conducts continuous research. Each is operated much like a separate company. Within these "companies"—whose interests range from heavy chemicals to plastics and textile fibers—college trained men and women work in congenial groups where they have every opportunity to display individual talent and capabilities. Who knows what their contributions will mean in the future to science and the world!

C. M. Olson, *Ph.D.Phys.Ch., Chicago '36, and C. H. Winter, Jr., B.S.Ch.E., Virginia Polytechnic Institute '40, removing 100-lb. titanium ingot from furnace in heat-treating study.*



R. C. Reidinger, *B.S.Ch.E., Princeton '47, and T. D. McKinley, B.S.Ch., Worcester Polytechnic Institute '35, making a test of the hardness of ingots of Du Pont titanium metal.*

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Edited by Otto de Lorenzi, Director of Education, Combustion Engineering - Superheater, Inc. Size 6¼ by 9¼. 1042 pages.

HOW TO GET IT. Although the list price of this book is $7.50, it is made available to engineering students at a nominal price. For particulars see the head of your mechanical engineering department or your instructor in heat power. Inquiries may also be addressed to the publisher.

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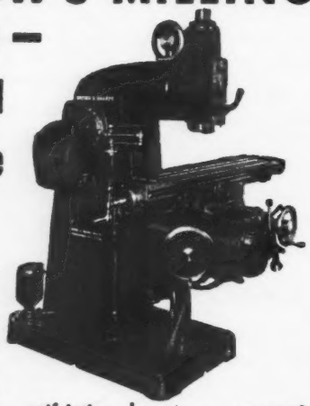

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wiener—paul bunyan of m. i. t.

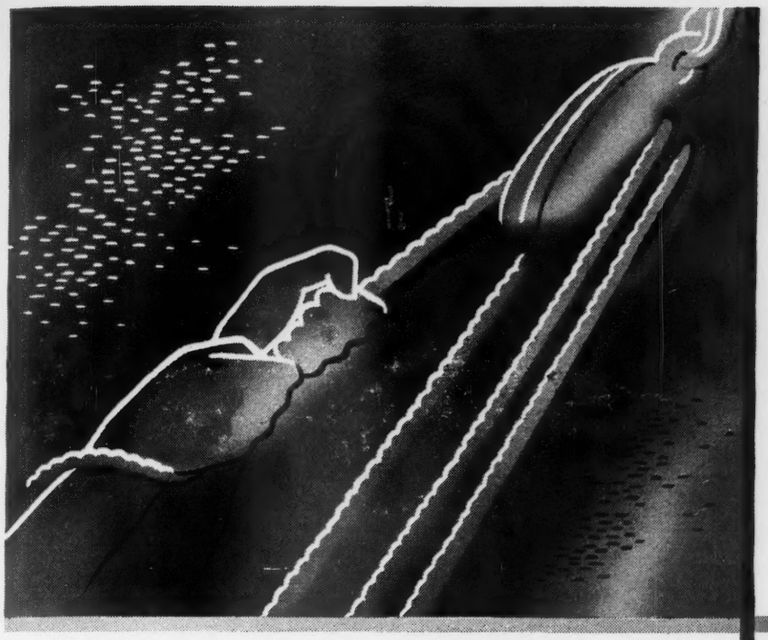
(*Continued from page 188*)

Nagasaki, has made it clear that to provide scientific information is not necessarily an innocent act, and may entail the gravest consequences. One therefore cannot escape reconsidering the established custom of the scientist to give information to every person who may enquire of him. The interchange of ideas, which is one of the great traditions of science, must of course receive certain limitations when the scientist becomes an arbiter of life and death."

Dr. Wiener then pointed out that the restrictions placed on the scientist were so strong that if they continued during peacetime the policy would lead to the "total irresponsibility of the scientist, and ultimately to the death of science."

He added that he would publish no future work which might do damage in the hands of "irresponsible militarists." Several months later, in a blistering interview published in the New York *Herald-Tribune*, he strengthened his position by declaring that he would engage in no further government research.

The Professor now asserts that he will not work in any project that might mean the ultimate death of innocent people. Decrying the use of science as a weapon, he warns that the "go-getters" are being attracted into science by "the money and power attached to scientific administration by the atomic bomb project and other parallel developments." He feels that the only way to preserve the ideals of science or any other institution is to be stubborn — to resist "the pressure of external order."



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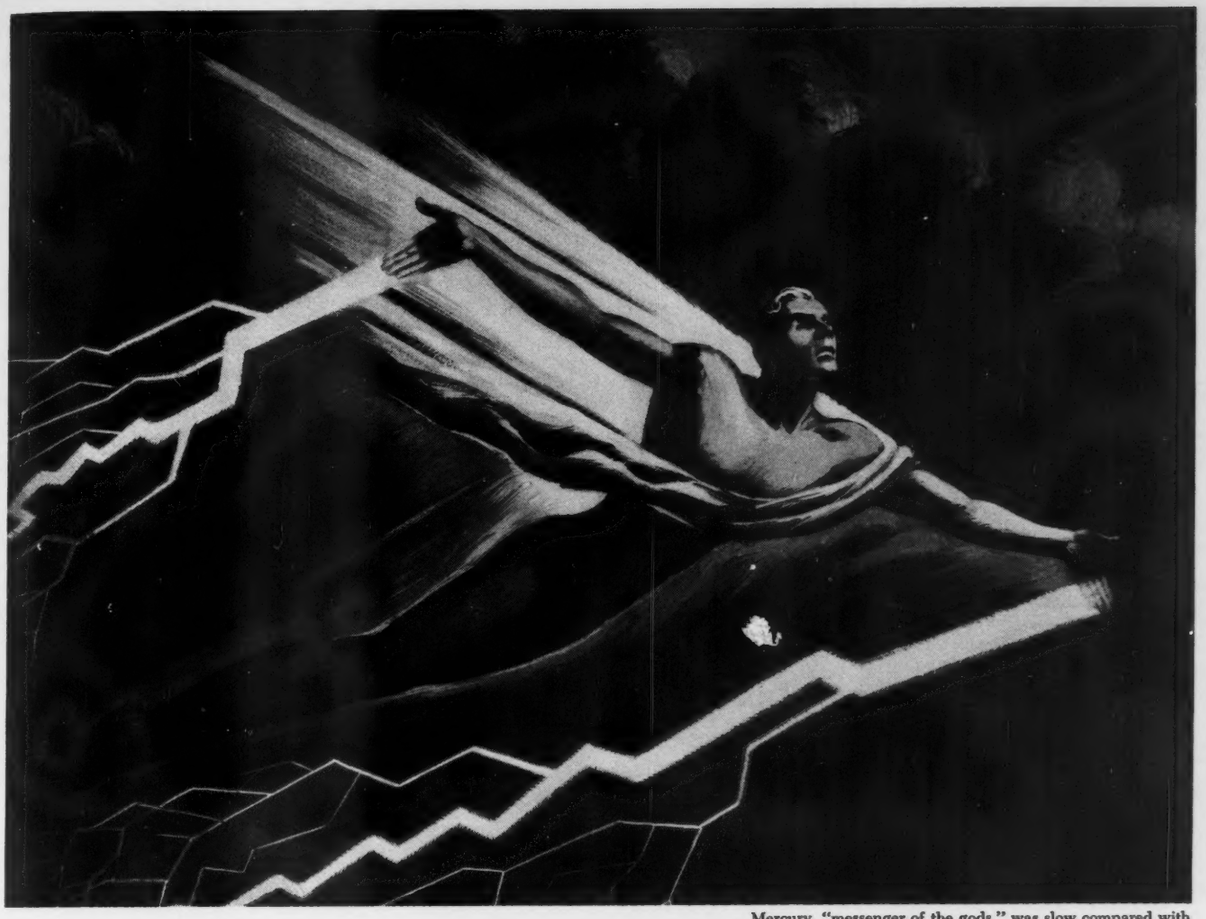
The ring test, shown above, is a scientific method for determining the modulus of rupture of pipe. It is not a required acceptance test but one of the additional tests made by cast iron pipe manufacturers to ensure that the quality of the pipe meets or exceeds standard specifications.

A ring, cut from random pipe, is subjected to progressively increased crushing load until failure occurs. Standard 6-inch cast iron pipe, for example, withstands a crushing weight of more than 14,000 lbs. *per foot.* Such pipe meets severe service requirements with an ample margin of safety.

Scientific progress in the laboratories of our members has resulted in higher attainable standards of quality in the production processes. By metallurgical controls and tests of materials, cast iron pipe is produced today with precise knowledge of the physical characteristics of the iron before it is poured into the mold. Constant control of cupola operation is maintained by metal analysis. Rigid tests of the finished product, both acceptance tests and routine tests, complete the quality control cycle. But with all the remarkable improvements in cast iron pipe production, we do not forget the achievements of the early pipe founders as evidenced by the photograph below of cast iron pipe installed in 1664 to supply the town and fountains of Versailles, France and still in service. Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction. Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3, Illinois.

Section of 285-year-old cast iron water main still serving the town and fountains of Versailles, France.

CAST IRON PIPE SERVES FOR CENTURIES



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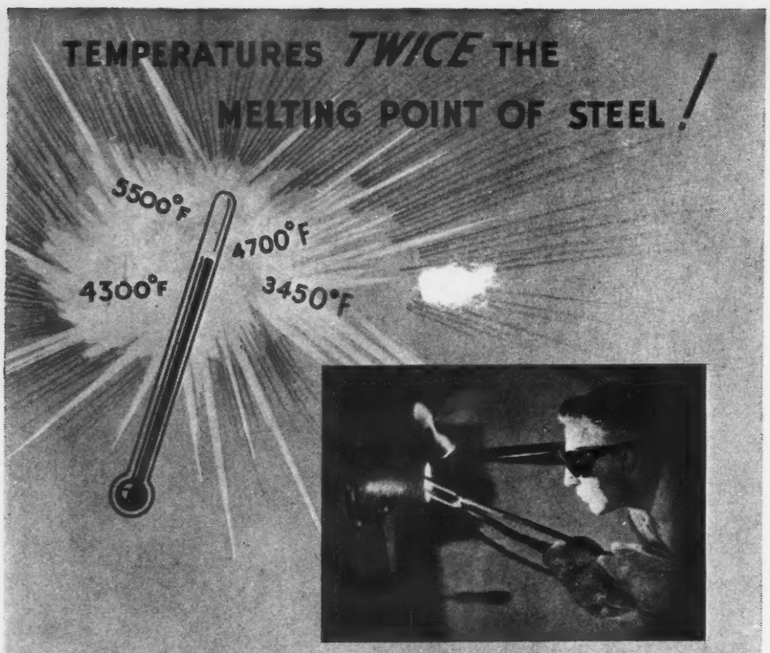

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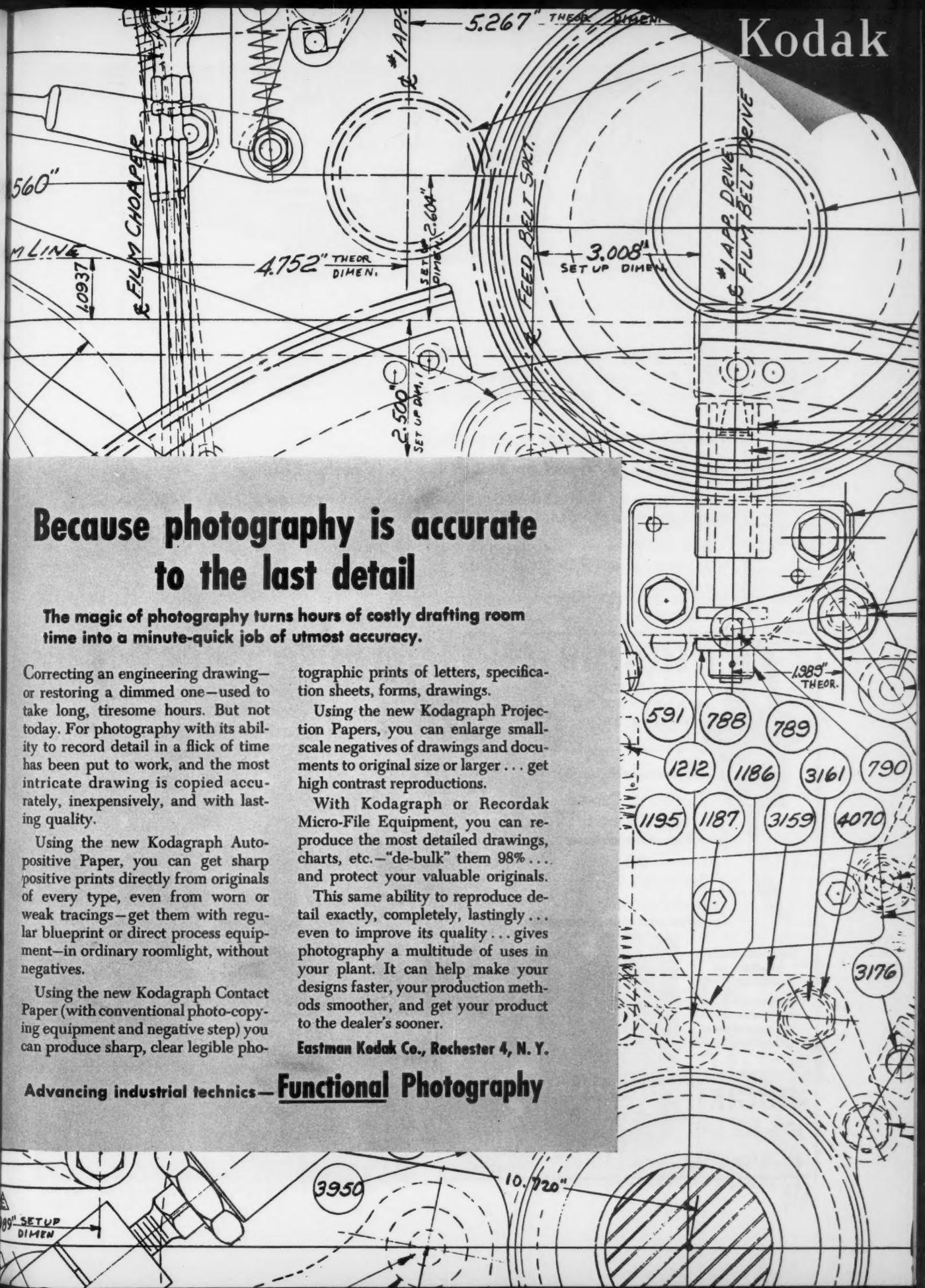
hot air goes to work

(*Continued from page 173*)

ments in the field of lubrication reduced friction to a minimum.

With all these improvements embodied in their new design, the Philips engineers came out with their new air engine. The accompanying drawing (Fig. 4) shows us construction and cycle of this modern air engine. Following through we observe readily that the cycle is the same as that of the Sterling engine, or for that matter, our imaginary air engine. The only different aspect in design when comparing it to the Sterling engine is that the working and transfer pistons use the same cylinder. This eliminates a lot of extra material, cuts down on heat losses and makes for an easier linkage connection of the two pistons. Thanks to this improved design and the developments which we saw above, this Philips air engine has been working with speeds of up to 3000 r.p.m., and had a reported efficiency exceeding that of gasoline engines of corresponding power. Although, as said, very satisfactory results have been obtained with the single cycle engine as described, some further research showed that some of the construction difficulties could be simplified by the use of a multi-cylinder engine. In the accompanying drawing (Fig. 5) we see a Philips multi-cylinder engine with four cylinders. In each of the four cylinders there is a hot space above and a cold space below it. Also each hot space of the cylinder is connected through heater, regenerator and cooler to the cold space of the next cylinder and thus when giving the pistons suitable phase differences we see that the transfer pistons can be dispensed with. This type of engine has an additional advantage of ease of reversibility. Of course those four cylinders do not of necessity have to be in a straight line as seen in the diagram. Actually, quite heavy heat losses would occur owing to the long passage between the first and the last cylinder and it has been found more convenient to place the cylinders in two "V's," very similar to some automobile engine.

We have thus covered briefly the principle, history and development of the air engine. We still are in the state of development and research and the outlook is promising. It is quite possible that in the very near future more will be heard and seen from the air engine and if it will not supersede other types of engines now in use, it will surely play an important part in industry.



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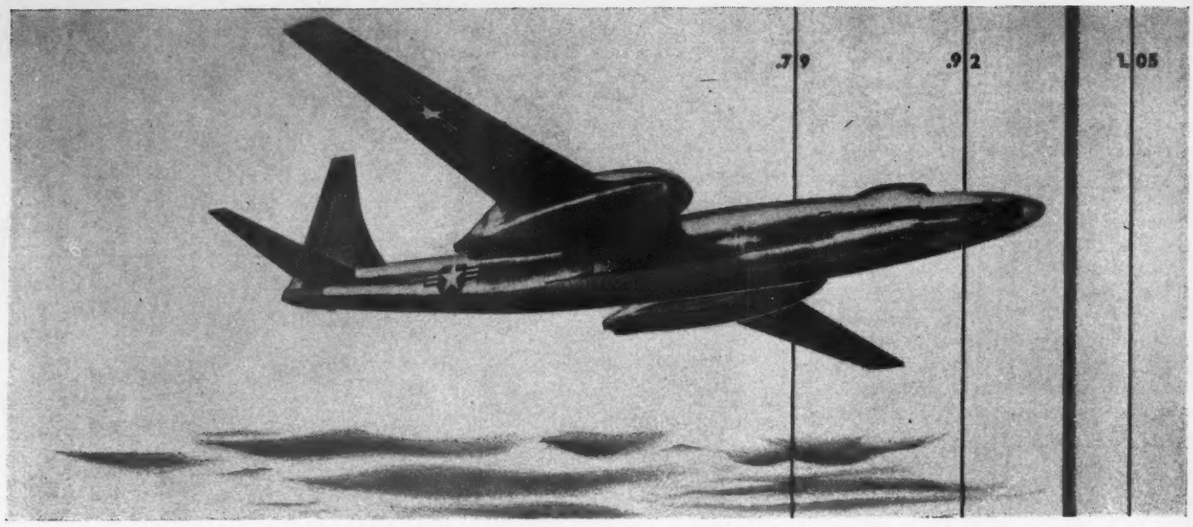

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This is another of the interesting and imaginative assignments that are solved at the desks and drawing boards of SKF Engineers. SKF Industries, Inc., Philadelphia 32, Pa. 6737

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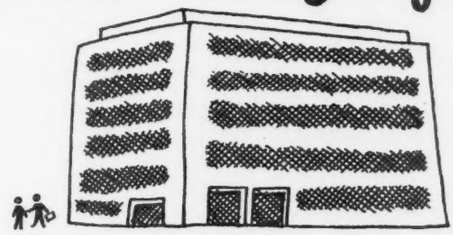

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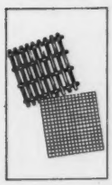

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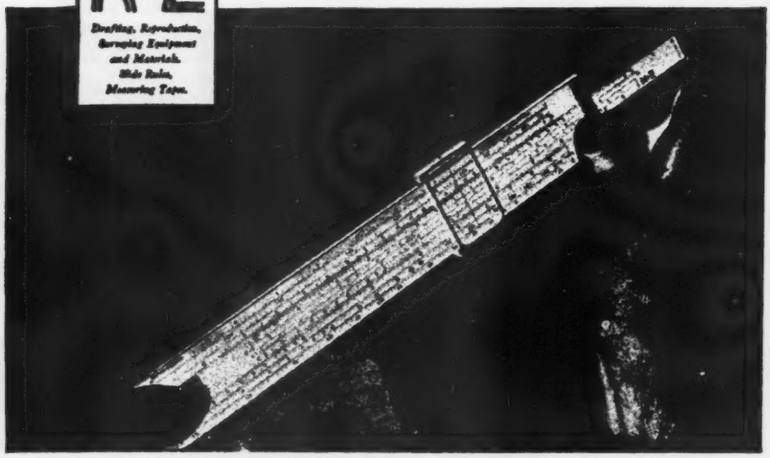

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the camera sees more

(*Continued from page 177*)

which would ordinarily be invisible. The usefulness of infrared photography in documentary photography is also due to the different transmission characteristics of various pigments with infrared and visible light. The results of photographing a document with infrared are usually unpredictable since the effect depends upon the type of pigment used. For instance, certain inks are penetrable by infrared, a fact which enables some censored documents to be deciphered from infrared photographs. On the other hand, some inks and also pencil writing are still opaque to infrared even after they have been made invisible to the eye by mechanical or chemical means. These phenomena make infrared photography useful in discovering forged documents. An example of this was recently cited in which a stamp forger was convicted after several thousand infrared photographs of stamps had been taken. Infrared photographs also reveal unexpected detail in photographs of charred documents and reveal lost writing

(*Continued on page 208*)

Engineers review design of a new petroleum project. E. R. Wilkinson, L. S. U. '34; O. R. Menton, L. S. U. '38; W. A. Whitaker, Virginia '25; H. C. Leak, Mississippi State '43.

They're mighty good men to have around...

In times like these, engineers like the four shown here are mighty good men to have on the job at Esso Standard Oil—where our 28,000 workers today *average* almost 14 years with the company.

Their extra measure of skill, experience and job loyalty has set amazing records in *production* to help meet the high demand for gasoline and heating oil and other products.

One reason these extra-good workers are here today is simply the extra-good jobs they have at Esso Standard.

Over 30 years ago, the company set up an unusual "good jobs policy." It was based on the belief that better jobs would mean better workers, and that would mean a better company.

Since then, with our workers, we have developed plans which give every Esso Standard worker such job advantages as these: ***uniformly good wage scales... vacations with pay... special benefits in case of sickness or accidents... chance to advance in the company... cash savings in a Thrift Plan...fair treatment at all job levels... and planned retirement with steady income assured for life.***

All this was done as a matter of good business. It has given good business results. Not a strike or major work disturbance in over 30 years. Steady, skilful workers on the job. The development of new products from petroleum. New records in production to meet the country's needs. Yes... they're mighty good men to have around.

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ESSO STANDARD OIL COMPANY

FEBRUARY, 1949

another achievement of Columbia's Technical Staff

Butoxyethyl Diglycol Carbonate—"BxDC"—is an important derivative of Diglycol Chloroformate. Developed by Columbia's Technical Staff, BxDC is living up to its laboratory potentials by serving as a valuable plasticizer in typical vinyl resins and butadiene-acrylonitrile copolymers. In addition, it is proving useful as a lubricant in Butyl rubber stocks compounded with the Columbia pigment, Silene EF, or other non-carbon pigments. BxDC also has excellent potentials as a high boiling solvent.

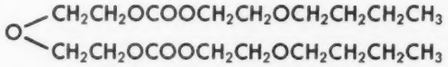
BxDC*

(BUTOXYETHYL DIGLYCOL CARBONATE)

COLUMBIA'S TECHNICAL STAFF, comprising Research, Development, Technical Service and Market Research, is continually engaged in developing useful chemical products—BxDC, for example—from Columbia's basic production of chlorine and alkalies. Pittsburgh Plate Glass Company, Columbia Chemical Division, Fifth at Bellefield, Pittsburgh 13, Pa.

***GENERAL CHARACTERISTICS OF BxDC**

[Diethylene Glycol Bis (2-n-Butoxyethyl Carbonate)]



Butoxyethyl Diglycol Carbonate is a new, colorless, liquid organic plasticizer. It is substantially insoluble in water and is very stable to hydrolysis by water. Only neutral products and carbon dioxide can be formed upon hydrolysis. It is soluble in a wide range of organic solvents and is further characterized by excellent resin compatibility, low volatility and high plasticizing efficiency.

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CAN YOU MAKE three pounds of steel do the work of four... and stay on the job longer? The answer is YES, with *alloy steels*—steels that are combined with small amounts of other metals, such as chromium, vanadium, and zirconium, to develop or increase desired qualities. For example, it's the element, *chromium*, that gives the stainless nature to steel.

So great is the improvement in steel, when alloy agents are used, that a freight car of alloy steel can weigh 25% less, haul heavier loads, yet stay in service much longer than similar cars of ordinary steel. Alloy agents not only increase the strength of steel, they also extend its life through reduction of destructive factors such as rust, corrosion, and wear.

The use of better materials to make steel go farther and serve longer is especially vital to all of us... with steel mills unable to catch up, and ore supplies dwindling.

Industrial gases have a big role in steel's better performance, too. Compressed oxygen aids in cleansing the molten steel... the oxy-acetylene torch cuts steel sections to size—and welds them together if desired. Finished steel articles are given a harder, longer-wearing surface through "flame-hardening." And carbon, in the form of electrodes, makes modern electric furnaces possible... with their output of high quality steels.

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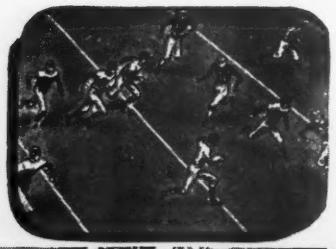

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for high dielectric and structural strength, light weight and ease of machining

In the RCA television camera, for example, Synthane was selected for coil forms, tubes, flanges and other components because of its electrical insulating properties, especially at high frequencies and high voltages. Its ease of machining, light weight and structural strength were other factors that led RCA's design engineers to select Synthane as the best possible material for this job.

Synthane, laminated phenolic plastic, is at its best in applications requiring unusual *combinations* of characteristics. Its excellent electrical insulating ability, combined with ease of machining, light weight, rigidity and many other properties, such as moisture and corrosion resistance, make Synthane a valuable material for many industries.

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Demonstrate Controllability of *GAS*

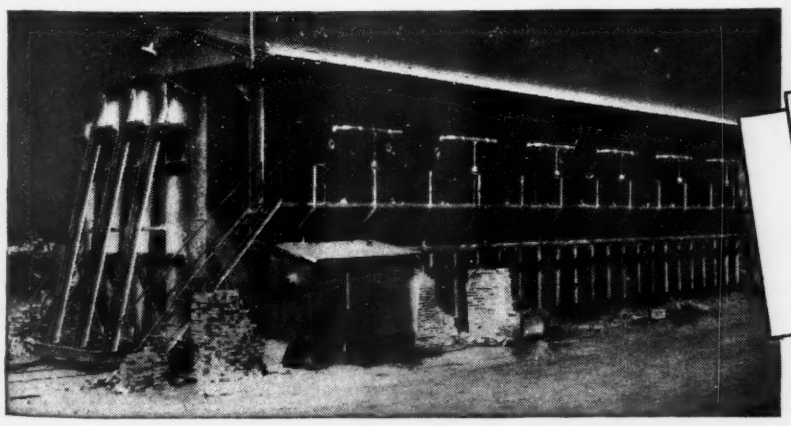
Safety codes govern many of the manufacturing and testing methods for pressure vessels. One of the most important processes, stress relieving, requires precise control of temperatures throughout the cycle—just the type of temperature control to be found in thousands of industrial applications of GAS for heat treating.

Specialists in the manufacture of pressure vessels depend on GAS for heat processing of all types. The pioneering firm of Black, Sivalls and Bryson, Inc., Kansas City, uses GAS in the manufacture of tanks, valves, pressure vessels and safety heads. President A. J. Smith says,

"Throughout the past 25 years we have depended on GAS to provide the exacting temperatures for our work. In many of our plants we have developed special GAS equipment; our large stress-relieving furnace at Oklahoma City is a typical example."

In this large furnace the GAS control system is arranged to provide temperatures up to 1200° F. for any time-cycle required. Automatic regulators and recording pyrometers assure maximum fuel efficiency while the flexibility of GAS is an important factor in maintaining production schedules on vital equipment.

Stress-relieving is just one of the applications of GAS for heat processing. You'll find hundreds of other uses for the productive flames of GAS—they're worth investigating.



MORE AND MORE...

THE TREND IS TO GAS

FOR ALL INDUSTRIAL HEATING

One of the largest stress-relieving ovens in the United States, this installation at Oklahoma City is 77' long, 12' wide, 18' high—Gas-fired and equipped with recording pyrometers.

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE **NEW YORK 17, N. Y.**

briefing the news

Shocking . . .

An oscillograph was recently used to demonstrate the discharge pattern of a South American electric eel. Some interesting characteristics of these eels were described to the American Institute of Electrical Engineers.

A potential of 600 volts is often achieved by this fish. Horses and cattle have been killed at watering places by the terrific jolt which the electric eel can produce.

Strangely enough, the eels are always positive at the head and negative at the tail. The charge is produced by three "electric organs." The electric eel has also been credited with radar ability. This statement is supported by the fact that eels are able to quickly locate their prey in murky water even though they have poor eyesight.

Plating Tungsten Alloys . . .

Tungsten alloys can now be plated on such metals as iron, copper, and brass, giving these metals an extremely hard, heat resistant outer surface which is useful where much friction and wear are encountered.

The method was developed by Professor M. L. Holland and Luther E. Vaaler, both of the University of Wisconsin. The alloys used were composed of from five to fifty-five per cent tungsten, along with nickel, cobalt, or iron. A method of plating pure tungsten has, as of yet, not been developed.

Alcohol Absorption . . .

According to a recent bulletin the State of Nevada leads the nation in per capita consumption of distilled spirits, wine and beer. Mr. John Public in Nevada absorbs more than three gallons of alcohol a year. Massachusetts is a poor runner-up in this poll with a consumption of 1.0–1.49 gallons per man per year.

Boston Traffic Plan . . .

A master highway plan for Metropolitan Boston has been drawn up by a board created for this purpose by the Governor of Massachusetts. This plan will include twenty-three cities and towns in addition to Boston. It is hoped that efficient movement of traffic will be made possible by the execution of this plan.

The plan was drawn up only after much field study of various traffic facilities, characteristics of traffic, cost estimates and alternate routes. Such factors as future population increases, zoning ordinances, trends of industrial expansion and topography received careful consideration.

The backbone of the transportation network is to be a system of expressways. There will be eight routes radiating from the center of Boston. A belt route will surround downtown Boston and part of Cambridge. The radial routes are distributed around the entire belt. The total length of the eight expressways and the belt route is 85.4 miles.

These expressways will require rights-of-way from two to three hundred feet in width. There will necessarily be three lanes in each direction in order to accommodate the expected traffic volumes. There will be grade separations at all important intersections. Elevated highway design is to be used in some sections.

The expressway network is to be supplemented by many other improvements. Extension of terminal parking facilities, coupled with an improved rapid transit system will greatly ease the downtown Boston traffic tie-ups. Relocation of certain markets is also planned. A tightened program of enforced parking regulations is recommended to keep traffic lanes clear. In addition, many thoroughfares are to be widened. A group of cross-town arteries is to be made one-way.

Total cost of the project is estimated at $356,000,000. This figure is the result of a comprehensive cost analysis.

The project can be completed in ten years. It is to be done in five stages. The first stage, for example, includes a Mystic River Bridge, an East Boston elevated highway, and an improved Embankment Road. Of these projects, the Mystic River Bridge and the elevated highway are now under construction; and detailed working plans have already been drawn up for the Embankment Road improvement.

More Tracers . . .

Having been applied to almost every other research problem, radioactive tracer elements are now being used in the study of atomic movement in metal crystals. In a recent experiment at the G.E. laboratories, radioactive silver 110 was plated on a silver block, which was later shaved to determine the depth of penetration of the plated atoms. It was found that atoms moving between the silver grains in the block moved as rapidly as one-tenth inch per week at 500 degrees Centigrade. Atoms passing through the grains take ten thousand years to move an inch, it was reported.

Thousands of Acres of Southern Farm Land Revitalized

Tennessee Coal, Iron and Railroad Company plays important role in task

FOR years, the devastating "one-crop system" robbed vast acreages of southern soil of the vital mineral elements which support plant growth. Cotton or tobacco raised in the same fields year after year had reduced the fertility of many southern farms to the point where the annual yield hardly paid for the seed and labor that went into production.

Among the things that agricultural leaders found in their efforts to build up southern agriculture was that Basic Slag —a by-product of open hearth steel, as manufactured at the Ensley (Alabama) Works of the Tennessee Coal, Iron and Railroad Company, a subsidiary of United States Steel Corporation — contained several important minerals, including phosphorus and lime. These elements are needed to grow bountiful crops and high beef and milk producing pastures.

Today, Basic Slag is in wide use as a convenient, economical soil builder. Together with the other soil-building programs of the agricultural agencies, it has helped the southern farmer to prosper.

Opportunities . . .

Here is another example of the important work being done by the United States Steel family. If you would like to take part in the widely-varied projects being conducted, why not see your Placement Officer for a copy of the book "Paths of Opportunity in U.S. Steel"?

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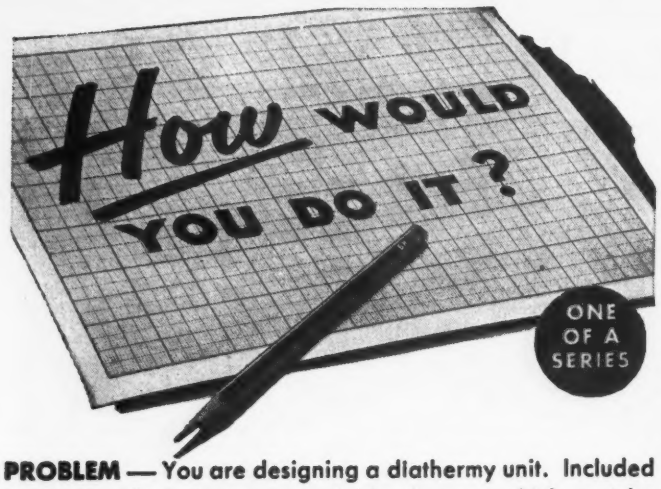
USS

UNITED STATES STEEL



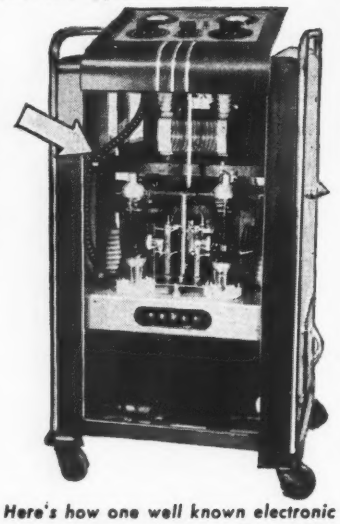
PROBLEM — You are designing a diathermy unit. Included in the electrical circuit are variable elements which must be adjusted during operation. The control knobs must be located where they will be convenient to the operator. The variable elements themselves must be located in the cabinet where they will be easy to mount, to wire and to service. How would you do it?

THE SIMPLE ANSWER — Use an S.S.White remote control type flexible shaft to couple each variable element to its control knob. This simple arrangement makes it possible to place the elements and their controls anywhere you want them. And you will find, too, that operation with these shafts is as smooth and sensitive as a direct connection, because S.S.White remote control flexible shafts are designed and built especially for this type of duty.

* * *

This is just one of hundreds of remote control and power drive problems to which S.S.White flexible shafts provide a simple answer. That's why every engineer should be familiar with the range and scope of these "Metal Muscles"* for mechanical bodies.

*Trademark Reg. U. S. Pat. Off. and elsewhere



Here's how one well known electronic equipment manufacturer did it. The flexible shaft (arrow) connects control knob at top to a variable element at the bottom rear.

WRITE FOR BULLETIN 4501

It gives essential facts and engineering data about flexible shafts and their application. A copy is yours free for asking. Write today.

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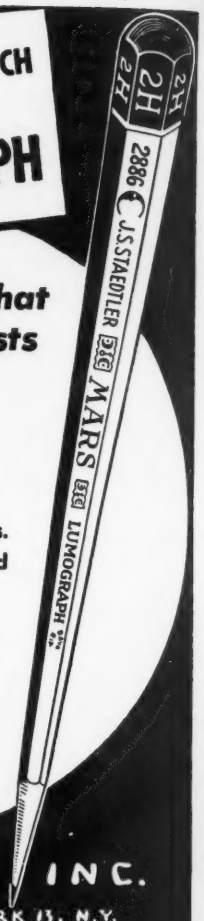

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the camera sees more

(*Continued from page 200*)

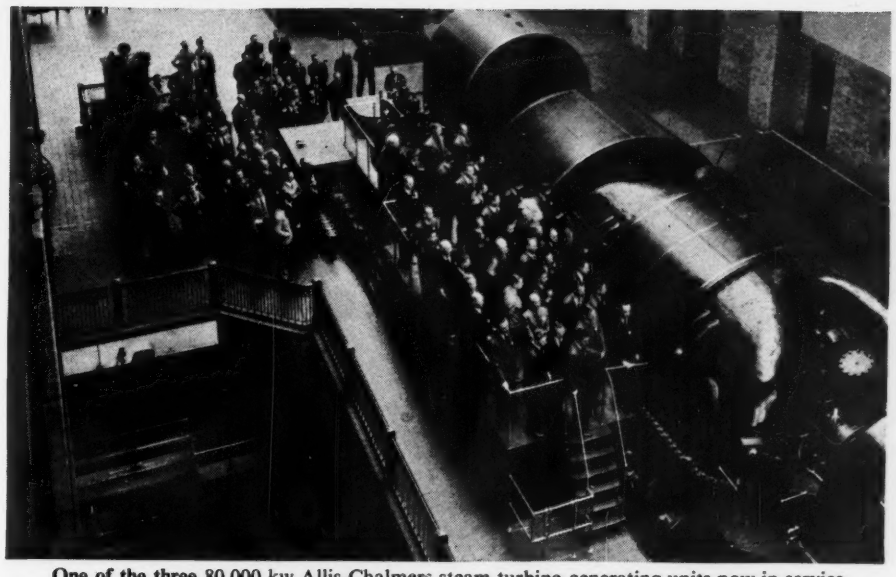
or fingerprints as shown in one of the illustrations. Still another criminological application of infrared photography is in burglar alarm and detection systems. Cameras are connected by relays to photoelectric cells. When the beam to the photoelectric cell is broken by an intruder the camera shutter is opened and a flashbulb, which is coated with a material transmitting only the invisible infrared part of the spectrum, is set off. Thus the picture of the intruder is taken on the infrared film in the camera without the intruder's knowledge.

One of the most useful applications for infrared photography in medical photography is in opthalmology. When the eye is photographed at a wavelength of about 8,100 Å, the deeply pigmented parts (trabeculae) register lighter than other parts of the iris. If atrophy takes place in the iris, resulting in the destruction of the pigment and its replacement by greyish-white tissue, a photograph made by infrared shows this region of the eye darker than the normal tissue of the iris. The brownish black pigments of the eye reflect infrared radiation to a greater extent than the visible radiation. Therefore it is possible to record abnormalities of the pupil margin by infrared photography. Thanks to the penetrative powers of infrared radiation it is possible to photograph the iris and determine its condition even when the cornea is clouded. Since infrared has no effect on pupillary diameter it is also useful in photographing the eye by infrared to determine the darkness adaption of the pupils.

Change Your Mind...

Most of us have, at one time or another

by J. L. SINGLETON
Vice-Pres. and Director of Sales, General Machinery Division
ALLIS-CHALMERS MANUFACTURING CO.
(*Graduate Training Course 1928*)



One of the three 80,000 kw Allis-Chalmers steam turbine generating units now in service in a big mid-western power plant. A fourth unit is being built, and a fifth is on order.

You may be one of those men who knows exactly the sort of work he wants to do when he finishes engineering school. I did. I was going into straight engineering work. But I became a salesman.

J. L. SINGLETON

I've noticed since that it's not unusual for Graduate Training Course students at Allis-Chalmers to change their minds. Here, opportunities have a way of seeking out a man according to his ability. Sometimes these opportunities are in fields that he had not fully understood or considered before. There are so many kinds of work to do here that a man is almost sure to end up in work that will bring him the most in personal satisfaction and advancement.

Opportunities in Selling

For example—sales. Not every engineer is a salesman, but at Allis-Chalmers every salesman is an engineer. Engineering plays a vital part in the sale of a big steam turbine, a cement plant—or even a multiple V-belt drive.

There's a thrill in landing orders—really big ones, such as two 115,000 HP generators for Hoover Dam—all of the rolls and purifiers for the world's newest and most modern flour mill—the world's largest axial compressor for use in a supersonic wind tunnel, or volume sales of small motors, pumps and drives. Orders like these come through teamwork of engineering, manufacturing skill, high-level salesmanship and merchandising. It's good to be a member of such a team.

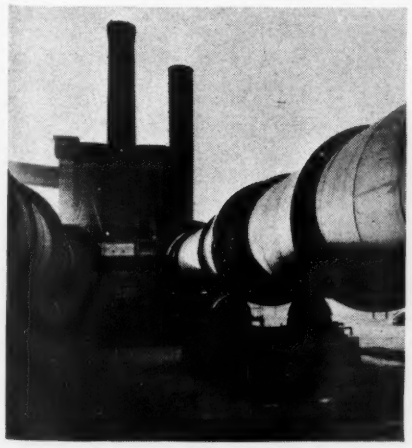
If you have ability and a leaning toward sales work, you'll have plenty of chance to test and develop it at Allis-Chalmers during your Graduate Training Course. Then you take your place in a Coast-to-Coast sales organization—perhaps even in a foreign office.

Many Fields Are Open

Or, maybe you'll change your mind. Research and development—or manufacturing—or design engineering may prove your field. The point I want to make is, all of these things are open to you at Allis-Chalmers. This company is in intimate touch with every basic industry: mining and ore processing, electric power, pulp and wood products, flour milling, steel, agriculture, public works.

The Graduate Training Course here doesn't hold you down. You help plan it yourself, and are free to change as you go along. You work with engineers of national reputation—divide your time between shops and offices—can earn advanced degrees in engineering at the same time.

Those are some of the things that appealed to me 23 years ago. They're still good.



Rotary Kilns are the most gigantic of all machines. Allis-Chalmers has designed and built kilns up to 475 feet in length, 12 feet in diameter—supplies all basic machinery for complete cement mills and processing plants.

Front-line man on the A-C team that designs, builds and sells basic machinery to all industry.

Write for details of the Allis-Chalmers Graduate Training Course—requirements, salary, advantages. Representatives may visit your school. Watch for date.

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Milwaukee 1, Wisconsin

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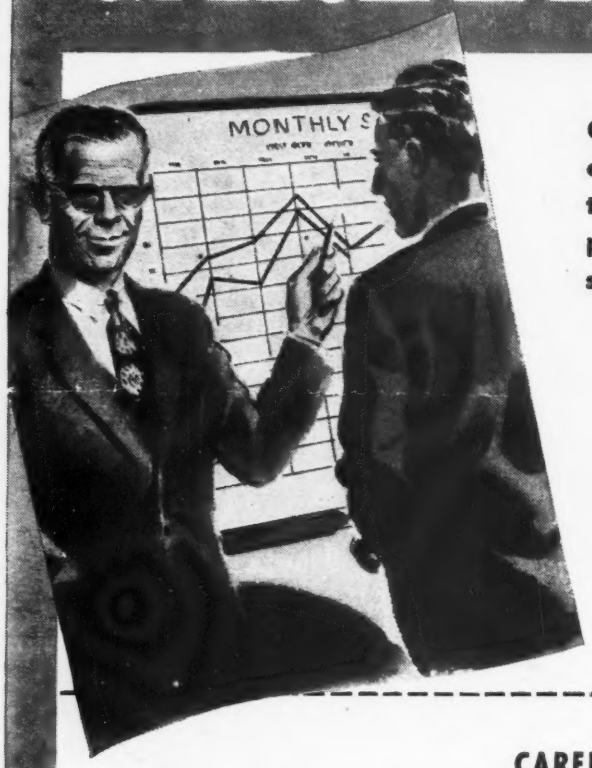
One of the Big 3 in Electric Power Equipment—Biggest of All in Range of Industrial Products

CAREERS AT GENERAL ELECTRIC



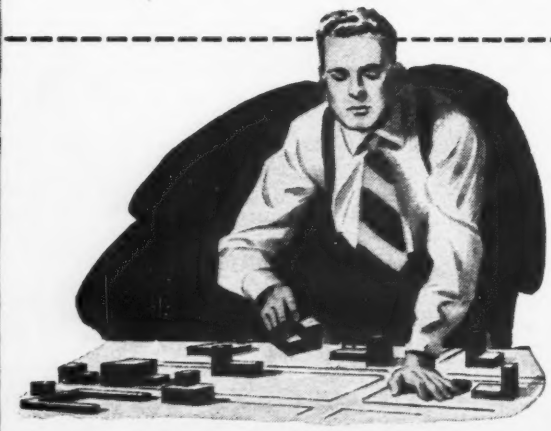
General Electric is not one business, but an organization of many businesses, offering opportunities in virtually all the professions. Here three G-E men brief the career-possibilities which the company offers to the marketing specialist, the accountant, and the manufacturing trainee.

FUTURES IN MARKETING

C. H. Lang (Michigan), Vice President responsible for all sales activities of Apparatus Dept.: "I believe that the need for increased sales efforts to maintain the current high level of business activity provides new and greater opportunities in the marketing of industrial products. Extensive training is offered in all phases of our marketing program—selling, application and service engineering, market analysis, and advertising and sales promotion."

CAREER IN FINANCE

H. A. MacKinnon, Assistant Comptroller and member of Company Education Committee: "New products coupled with the company's growth are providing excellent openings in business management. Since 1919, our Business Training Course and travelling auditors staff have provided direct channels through which young men have progressed into all types of accounting and financial management positions with General Electric."



MANUFACTURING TRAINEE

Dick Saunders (Rochester): "As a member of the G-E Manufacturing Leadership Program, I'm getting the know-how of manufacturing through 'personal apprenticeships' to seasoned managers. These varied assignments have included sitting in on labor relations meetings, handling grievances, taking time studies, establishing production schedules, and operating machine tools. It's the best way I know to learn the working of a complex business."

For further information about a BUSINESS CAREER with General Electric, write Business Training Course, Schenectady, N. Y.—a career in TECHNICAL FIELDS, write Technical Personnel Division, Schenectady, N. Y.

GENERAL ELECTRIC

National Bureau of Standards
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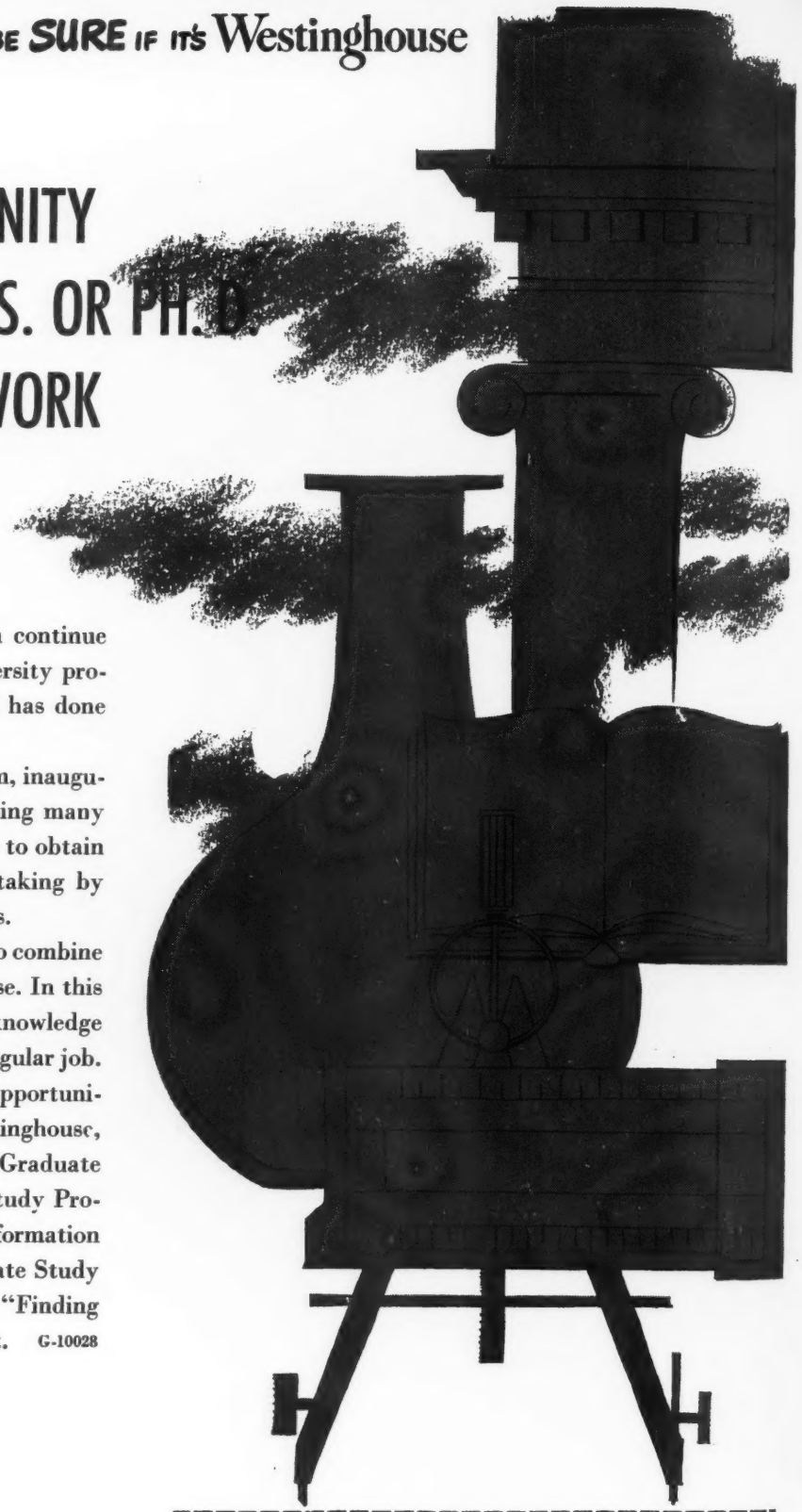
YOU CAN BE **SURE** IF IT'S Westinghouse

AN OPPORTUNITY TO OBTAIN YOUR M. S. OR PH. D. WHILE YOU WORK



Not all men qualified for graduate work can continue their advanced study under a full-time university program. Westinghouse recognizes this fact and has done something about it.

The Westinghouse Graduate Study Program, inaugurated in 1927, has been instrumental in helping many Westinghouse employes realize their ambition to obtain an M.S. or Ph.D. degree. It is a joint undertaking by Westinghouse and several leading universities.

The Graduate Study Program enables you to combine advanced study with your job at Westinghouse. In this way, you can apply advanced fundamental knowledge to solve the problems you encounter on your regular job.

Get complete information about the many opportunities offered engineering graduates at Westinghouse, including the advantages offered through the Graduate Student Training Course and the Graduate Study Program leading to higher degrees. Complete information is given in the booklet, "Westinghouse Graduate Study Program". You may also want a copy of, "Finding Your Place in Industry". Use coupon at right. G-10028

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To obtain copies of "Westinghouse Graduate Study Program" or "Finding Your Place in Industry", consult Placement Officer of your university, or mail this coupon to:

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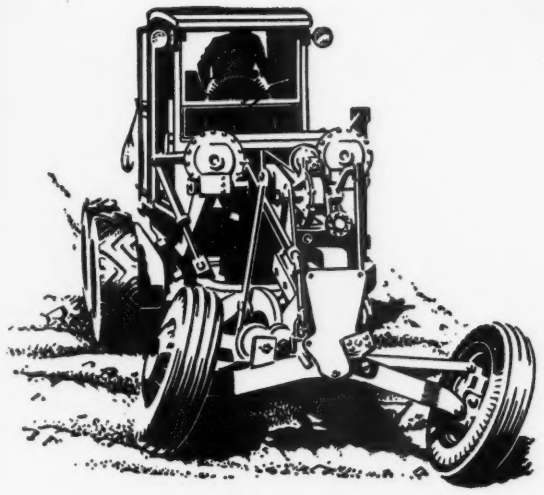
College_____ Course_____

Address_____

City_____ State_____ 6-3

Another page for **YOUR BEARING NOTEBOOK**

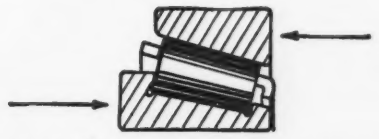


How to get a good steer from a grader

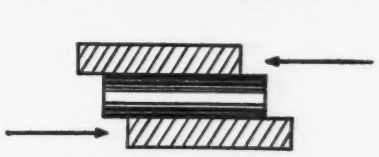
To make motor graders easy to steer, and to carry the weight of the front end, leading construction equipment manufacturers use Timken® tapered roller bearings in the king pin yokes. Timken bearings carry the heaviest radial and thrust loads in any combination, no matter how tough the going gets.

TIMKEN® bearings carry both radial and thrust loads

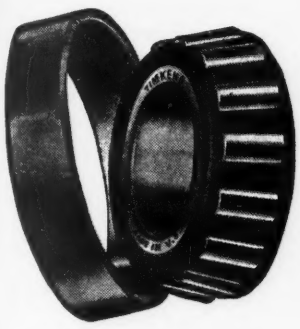
From whatever direction loads may come, Timken bearings can carry them. That's because Timken bearings are tapered in design. There's no need for special thrust bearings or washers. All combinations of radial and thrust loads are carried with frictionless ease. Shafts are held in perfect alignment, deflection and end-play are eliminated.



TIMKEN® TAPERED ROLLER BEARINGS



STRAIGHT ROLLER BEARINGS

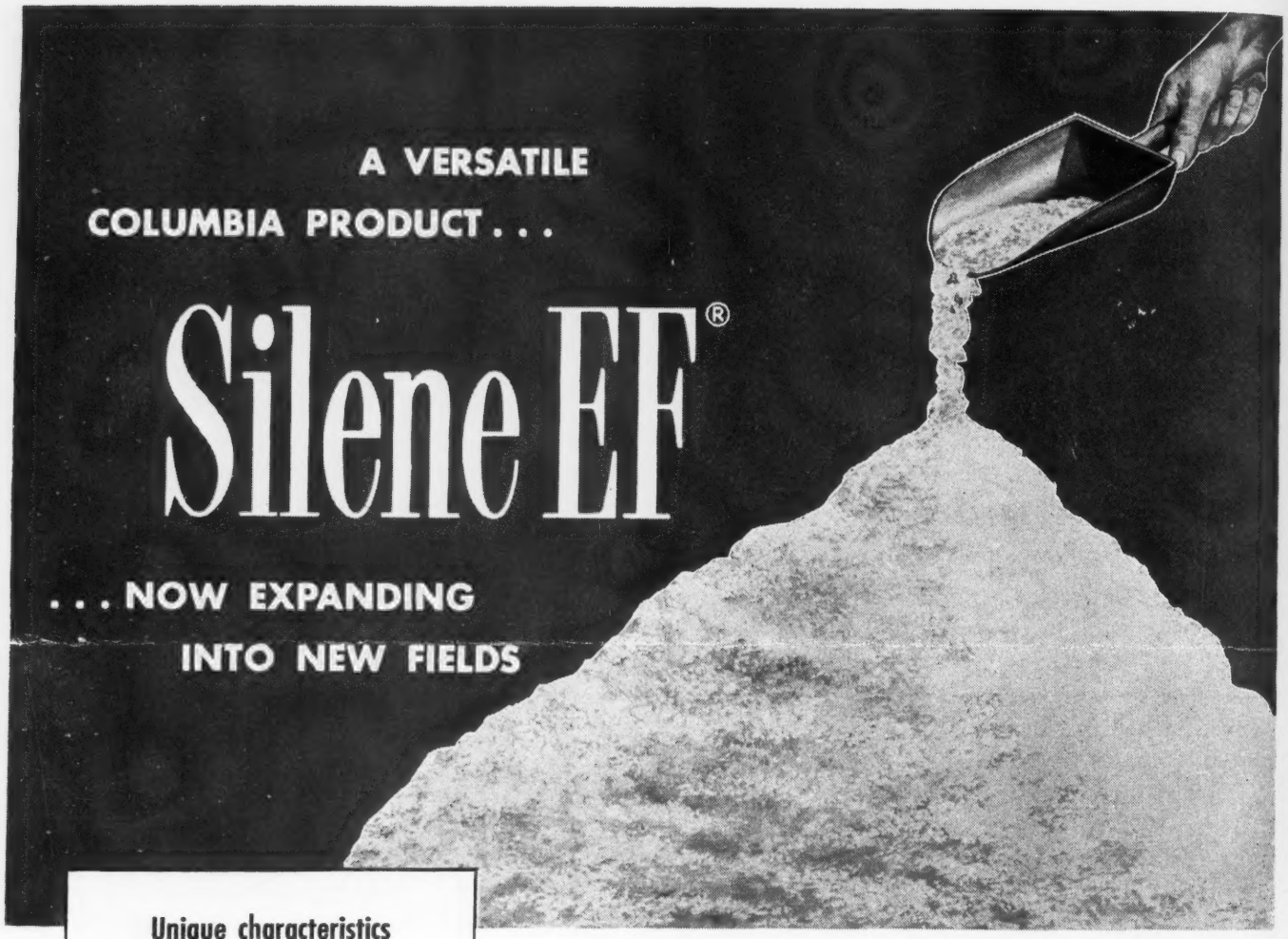


TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Want to learn more about TIMKEN bearings?

Some of the important engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'd be glad to help. For additional information about Timken bearings and how engineers use them, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬭ AND THRUST ⬭ LOADS OR ANY COMBINATION ✳



Unique characteristics indicate broad potentials for Silene EF

Silene EF is a white, very finely divided, precipitated hydrated calcium silicate with the following approximate analysis:

CaO	18.5
SiO_2	64.0
Loss on Ignition	16.5
Alkaline Reaction	pH 10.1
Particle Size	.035 microns
Bulk Density	15 to 16 lbs. per cu. ft.
Specific Gravity	2.1
Refractive Index	1.472
Oil Absorption	120-130

Silene EF has already served with exceptionally outstanding results in such applications as:

Reinforcing pigment in rubber
Anti-caking agent
Acid acceptor in plastics and rubber
Adsorbent in chromatographic analysis
Suspending agent

Throughout the war, Silene EF was used predominantly by the rubber industry and continues to be in increasing demand in this field. However, expanded production is now providing additional volumes of Silene EF for other uses. Thus the product re-enters a highly interesting phase of the work of Columbia's Technical Staff, comprising Research, Development, Technical Service and Market Research, where entirely new applications will be the goal. Pittsburgh Plate Glass Company, Columbia Chemical Division, Fifth at Bellefield, Pittsburgh 13, Pa.

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CHICAGO BOSTON ST. LOUIS PITTSBURGH
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Scene from the Alcoa Technicolor Film, "Unfinished Rainbows", starring Alan Ladd as Charles Martin Hall with Janet Shaw as his sister Julia. Available on request for your church, school or organization. Address Gulf Building, Pittsburgh 19, Penna.

ALAN LADD now co-starring in "WHISPERING SMITH", a Paramount Picture. Color by Technicolor.

How a group of American pioneers has held the price of Aluminum down

Charles Martin Hall, founder of America's aluminum industry, had a special kind of gleam in his eye. Every one of us has it too.

He was bound and determined to find a way to make aluminum cheaply. The schoolbooks all tell how he did it, where the world's greatest scientists failed.

Bluntly speaking, Charles Martin Hall set out to cut the world price of aluminum.

He was the first of the men and women of Aluminum Company of America. He licked a process. We who followed him—engineers, chemists, metallurgists, physicists, production experts—have been at it ever since.

But the gleam is the same. It's bumping elbows in the research lab with men who, in fifty years, have accomplished most of the finding-out that took fifty centuries, with the age-old metals.

It's working in the mill and having it seem that every shining sheet racing over the rolls is your own.

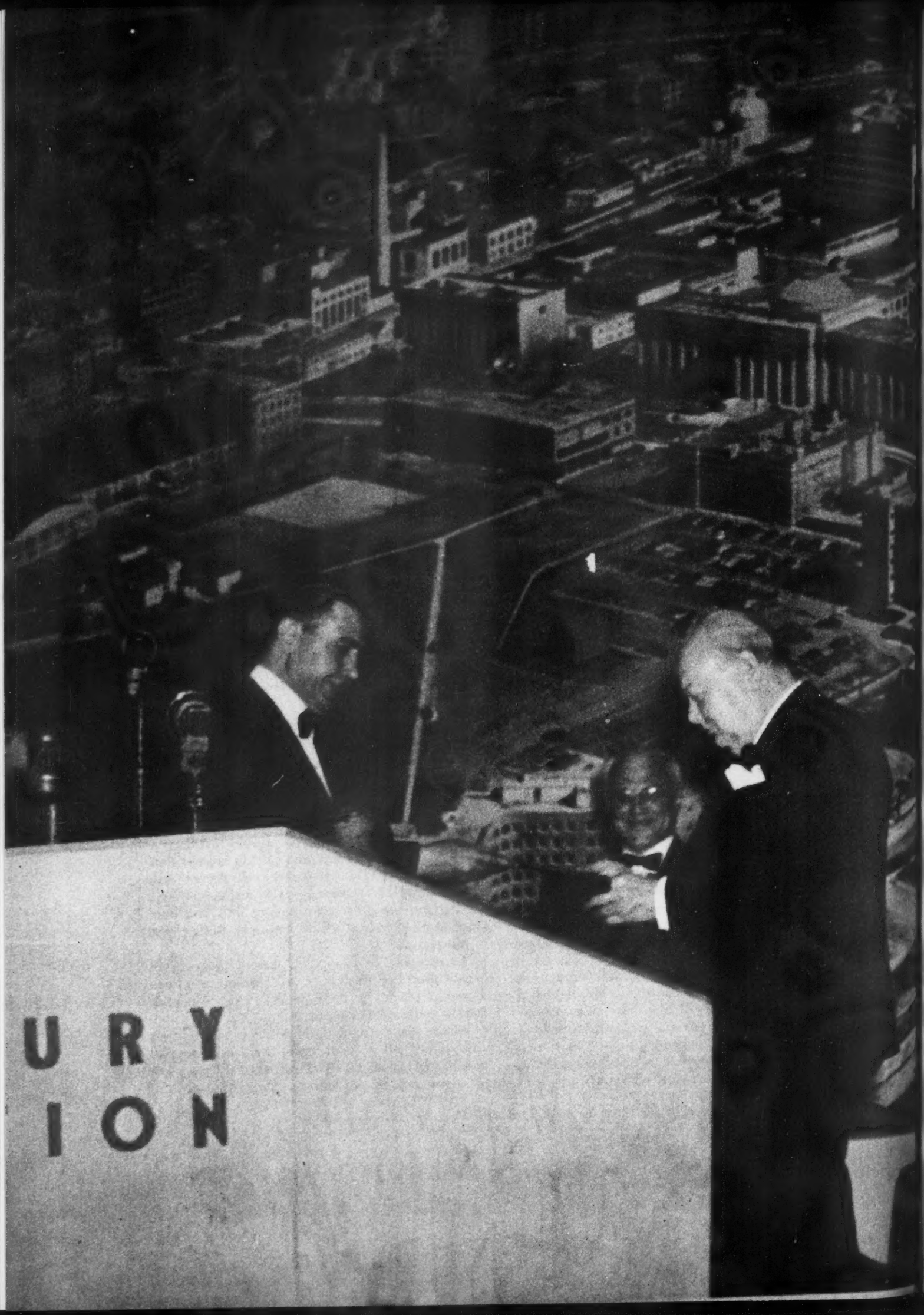
It's typing a letter in answer to a simple query, and having the deep-down feeling that you may be in at the birth of a new business, taking root in aluminum.

We propose to keep on being pioneers in broadening the usefulness of aluminum. Alcoa Aluminum sold in 1939 for 20 cents a pound. It sells today for 16 cents.

We are pioneering with microscopes and calipers and rolling mills. We'll stack them against axes and squirrel rifles and spinning wheels, for a place of importance in the history of our America.

To know other stories of the Alcoa family and the growth of aluminum's usefulness to you, write for free copy of "Aluminum—Its Story," ALUMINUM COMPANY OF AMERICA, *Gulf Bldg., Pittsburgh 19, Pa.*

ALCOA FIRST IN **ALUMINUM**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the tech engineering news

April 1949
Vol. XXX No. 6

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industrial research in action

By Kenneth King, '52

Downstream from the Massachusetts Institute of Technology is situated a company that pioneered industrial research at a time when research in industry was practically unknown. Arthur D. Little, Inc., as it is known today, stemmed from a small two-room laboratory opened in 1886 by Arthur D. Little, then recently graduated from Tech, and Roger B. Griffin, analytical chemist. The business of the partnership was to be that of consulting and analytical chemists. Gradually, with the advent of large corporations, the analytical phase of the work was overshadowed by the consulting practice and in 1938 analysis was discontinued entirely.

After World War I, American industry exhibited an increasing interest in research, and soon laboratories for this purpose were established within leading companies. Undoubtedly, this interest had been cultivated to a large extent by Dr. Little's efforts and accomplishments. In addition, direct aid from his organization helped to establish such large laboratories as the first actual laboratory of the General Motors Company and the Forest Products Laboratory. Thus, Arthur D. Little, Inc., now operates primarily as a consulting research and engineering firm. It conducts research for its clients, mostly large American industrial corporations, and cooperates with the clients' own laboratories by pioneering new fields, supplementing personnel and facilities, and offering a new perspective on their operations.

The research and development work at Arthur D. Little, Inc., is not confined to any particular field of science. In fact, its clients include steel companies, drug manufacturers, food producers, heavy chemical plants, radio makers, and machine-tool companies. Consequently, the research personnel is organized into a number of groups according to fields of applied science; namely, the Industrial Chemistry, Mechanical Engineering, Organic Chemistry, Food, Biology, Physics, Plant Engineering, and Technical-Economic Groups.

The research and development work with one of the organization's most unusual clients, the Puerto Rico Industrial Development Company, requires the close cooperation of all the above groups. At the present time Arthur D. Little and the P. R. I. D. C. together are literally industrializing the island of Puerto Rico. This extensive project had its inception in 1942 under pressing economic circumstances.

Since 1898, the Island's population has more than doubled and is still rapidly increasing. Economic development, on the other hand, has lagged far behind the population growth, thereby creating a chronic excess of available employees over the number of jobs. From one reason or another, private capital in Puerto Rico has been reluctant to assume the risks involved in new industrial undertakings. Because this condition prevails on the Island, the Government was forced to take the lead in a program of industrialization and, therefore, in 1942, established the Puerto Rico Industrial Development Company. This company is an operating agency empowered to start new industries on its own initiative and to assist private industrial enterprise by providing essential information and research.

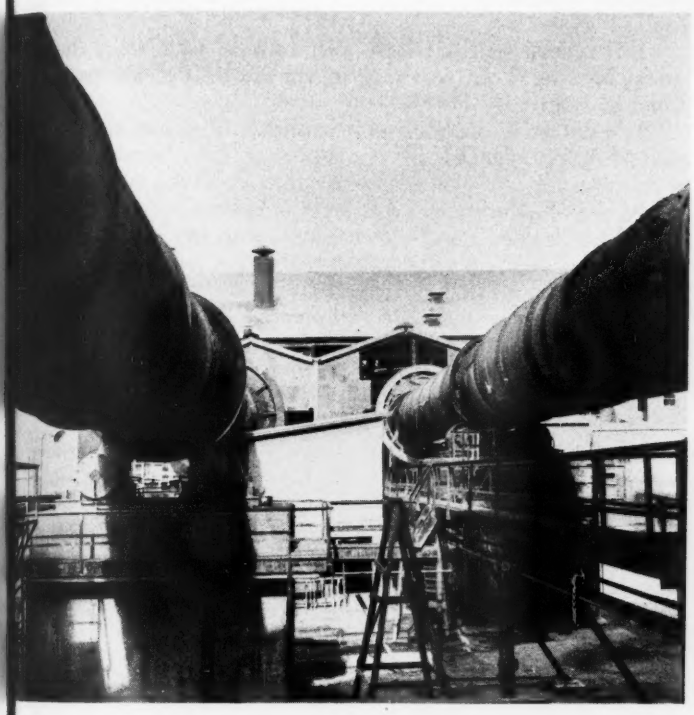
In order that the collection and correlation of the "essential information and research" be done in a thorough and expert manner, the P. R. I. D. C. consulted Arthur D. Little, Inc., in June, 1942, rather than undertake the entire project alone.

A preliminary study of the industrial possibilities of the Island was first made by research personnel of Arthur D. Little, Inc. The specific objectives of the survey were:

1. To find manufacturing industries which could be operated profitably in Puerto Rico.
2. To suggest individuals or concerns which would be capable of, and interested in, developing these industries.
3. To analyze and supplement available facts bearing on the attractiveness of such developments.

The Puerto Rico Cement Corporation — now producing cement for the world's largest housing project.

Closeup of the kilns at the cement company's San Juan plant.



4. To take any preliminary steps incident to the above that might assist in the introduction and development of new industries in Puerto Rico.

Following the preliminary report, more intensive investigations were made of the industries appearing to offer the greatest possibilities for broad utilization of natural resources and available labor.

Even after the Company began to function as an active organization, the possibility of persuading private businessmen on the Island or the mainland to expand their industry on Puerto Rican soil seemed unlikely because of the complete concentration on war production. Rather than delay the proposed program, the P. R. I. D. C. decided to set the precedent. Starting with a modern cement plant taken over from a Federal agency, the Company proceeded immediately to set up several new industries. Throughout the growth of these subsidiaries of the Company, constant contact was kept between the P. R. I. D. C. and its consultants, Arthur D. Little, Inc. Not only did the latter conduct strictly technical research and development in the laboratories, but also in the technical-economic aspect of the various problems which arose. In its phase of the work, the Technical-Economic Group performed valuable evaluations of possible industries concerning the size of prospective markets, status of competition, appropriateness of product characteristics, and adequacy of raw materials. In other words, both the technical and economic factors concerning a particular industrial situation were considered together, thereby offering a complete picture of existing or probable circumstances.

Consequently, the Puerto Rico Industrial Development Company, aided by the advice of the consultants, now operates five subsidiaries: Puerto Rico Pulp and Paper Corporation, Puerto Rico Cement Corporation, Puerto Rico Glass Corporation, Puerto Rico Shoe and Leather Corporation, and the Puerto Rico Clay Products Corporation. Up to the present time, the Company has operated these industries with results that are more than encouraging. The operation of these plants is certainly a step in the right direction.

The main purpose of P.R.I.D.C., however, is not merely to operate a number of plants itself. Rather, its primary intention is to show private capital the way to profitable investment, to give encouragement in the selection of the most feasible projects, to share risks, and to work in friendly cooperation with private capital in Puerto Rico.

Naturally, there will be cases in which, because of great individual hazard, private capital will be unwilling to invest. In other and more exceptional cases opportunity for profits may not be sufficiently attractive to induce investment of private capital in a particular industry. Only when new industries cannot be established by private capital alone would the Company itself undertake industrial projects, always providing that the projects will tend to improve the standard of living on the Island. Now, the program is based upon the participation of private capital. Since 1942, thirty-eight private factories have been undertaken with the financial aid of the Development Company and those currently operating are said to employ 8,284 workers.

The financial aid given to these thirty-eight factories was a part of the Aid to Industrial Development Program, started by the Company in September, 1945. Under the original AID Program new factories were constructed free of cost for eligible private enterprise and leased at low rentals, and at any time during the contract could be bought at cost price by the manufacturer. With the influx of new industry, however,

(*Continued on page 24*)

revolution in yachting

By Charles Saltsman, '52

New Materials Replacing Wood

Cursing softly to himself, Tom Gordon dropped his tattered piece of sandpaper and began to edge slowly backwards, out into the world again. He had spent all morning crammed mercilessly into the rope locker of the *Porpoise*, scraping, sanding, caulking, and cleaning the boat's battered timbers. To a six-foot yachtsman, the job seemed a close approximation of the existing conditions in hell. At least the job was finished. Tomorrow he would be able to paint the walls of that blasted locker, and then he'd be ready to start in on the main cabin. He mumbled bitterly. At this rate, the boat wouldn't be in the water before Christmas. He reached the tiny lavatory, where the sink greeted him with a hearty crack on the knee. Discomfort rapidly changed to anger. He could nearly stand now, but his legs, folded up in the bow for several hours, nearly buckled as he tried to do so. Growling louder than necessary, Gordon stumbled through the main cabin and back into the sunlight.

Reaching the cockpit, he straightened, smeared the sweat about on his face, and surveyed the boatyard. All about him were scores of yachts, large and small, scattered in a confused order, and from nearly every one of them came the sounds of spring cleaning. The warm June air was filled with the noisy chatter of saws, hammers, scrapers, and swearing yachtsmen. His eyes moved from one boat to the next, resting on each only long enough to estimate when it would be finished and ready to sail again.

"Hello, Tom."

Gordon's eyes turned in the direction of the voice. It belonged to Bill Aikens.

"Lo, Bill, how's your tub coming?" His voice came dry and harsh with disuse.

"Swell. Been in almost a week. Thought I'd go for a spin this afternoon."

"In already? You must have spent all winter on her."

"Nothing like that. Couple hours getting the cover off and cleaning her. Don't have to paint plastic, you know."

Bill turned with a laugh, and ambled off toward the dock, leaving Tom seething in the cockpit of his half-finished boat.

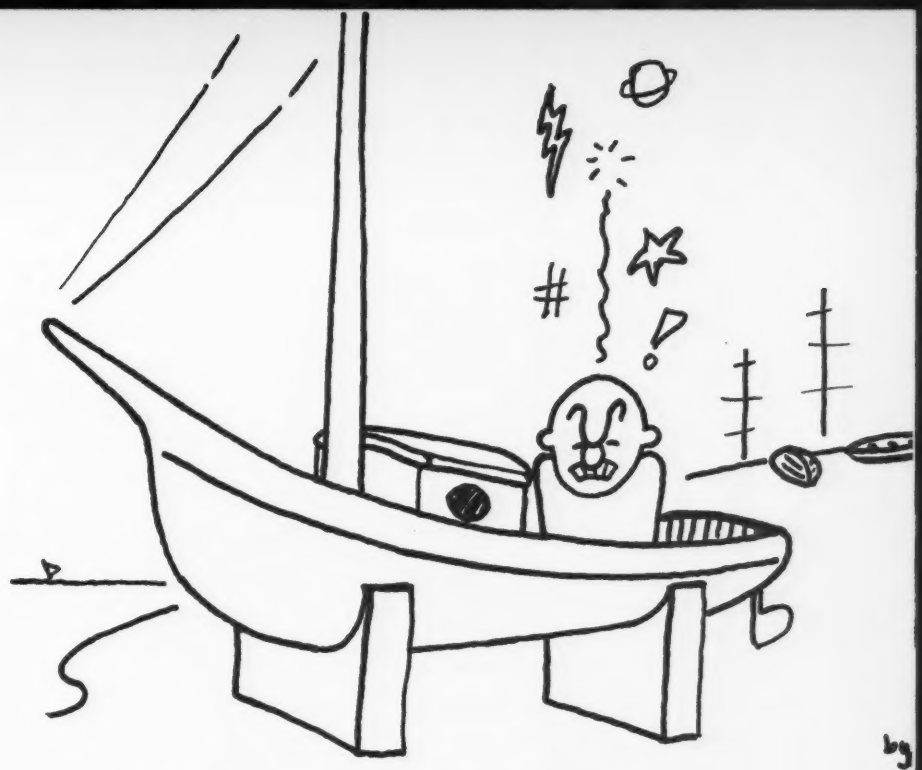
It's not as impossible as it sounds. The use of such materials as plastics in boatbuilding has become so widespread in the past few years that even the staunchest of the wooden boat advocates is beginning to sit up and take notice. And the construction methods used in boats, which, up until a few years ago, were virtually the same when Noah knocked the Ark together, have suddenly been completely revolutionized. The causes of this revolution, still in its infancy, are simple enough, but the results are still hazy.

To begin with, one must realize that the sport of yachting was, not so long ago, pretty much restricted to the very wealthy classes of people. If you owned a yacht, you also owned a large thirty-room shack on Long Island, you wintered in France, and you had influential friends in Philadelphia. But sometime after the First World War, society became a little confused, and the boatbuilders of the country discovered that they were building more and more boats for people who didn't even know J. P. Morgan. Furthermore,

Steelcraft's new thirty-five-foot cruiser accommodates six and has a top speed of twenty-six miles an hour.

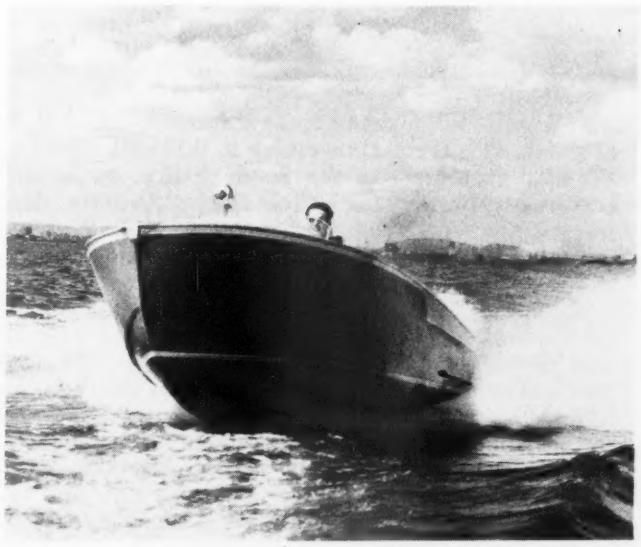
Courtesy Churchward and Co., Inc.

"The yachtsman does not want to be forever repairing his boat."



This twenty-foot utility runabout tops thirty miles per hour. It has a steel hull.

Courtesy Churchward and Co., Inc.



the boats that they were building were decreasing in size. There were few indeed who wanted to pay for the enormous upkeep of a large sailboat or motor cruiser, even if the initial cost of such a craft was low. It was not long before naval architects and yacht designers were bending every effort to meet the demands of the "small yachtsmen." Stronger boats, cheaper boats, faster boats: these were only a few of the things they wanted. Before the last war, so many people had become interested in sailing, that there were probably more pleasure boats in this country than in the rest of the world combined. But it was the war itself that started the change in the construction of these boats. During the vastly intensified research that the war brought about, many new materials were discovered, and today a few of these are widely used in boatyards.

The more important of the list are improved steel, aluminum, magnesium, plywood, and plastics. A brief study of each of these will show why they are threatening to replace completely the old wooden boats.

While boats made of steel are by no means new, they are far more popular today than they were a few years back. No longer does the yachtsman resort to metal construction only when a vessel is large enough to make wood impractical. He now thinks of a steel cruiser in terms of strength, economy, and safety. The use of steel, combined with the principles of mass production, borrowed from the automobile industry, have made these things possible. A modern steel boat costs little more today than an expensive automobile, and its strength, compared with a wooden yacht, is little short of phenomenal. Picture, if you can, what would happen to a wooden boat if left to pound against a stone breakwater. In a few hours there would be little left with the exception of a trace of driftwood. In testing the strength of steel hulls, a cruiser was put in the same situation for more than two days. Result — a few dents and a little less paint.

Probably the best known of today's steel cruisers are those built by Churchward and Company, of West Haven, Connecticut. In the past three years, this concern has produced more than two thousand of the famous "Steelcraft" boats. They are fabricated from copper-bearing "Otiscoloy" steel, a metal which has a high resistance to salt water corrosion. The plates are electrically arc-welded together, forming a perfectly water tight shell. The framing is made up of several longitudinal stringers with a few bulkheads for added transverse reinforcement.

With all the improvements that have been made possible through the use of steel, there are still a few arguments against its use. The first is that even though the metal used does not corrode or rust readily, it must still be kept well painted to avoid damage from salt water. The second lies in the personal preferences of the individual yachtsman. To many, the history and tradition behind wooden ships is enough to make them a bit wary of new materials. But the advantages far outweigh the disadvantages, and with time, the ports of America will probably become more and more crowded with steel boats.

In many respects, aluminum and magnesium are much like steel. The boatbuilder must be careful which alloys he uses, or he may find his vessels rusting at their moorings. After the Second World War, for example, the government offered large supplies of surplus aircraft aluminum to the country's shipyards. The metal, containing too much copper, corroded quickly in salt water, and consequently could not be used.

In the cases of both aluminum and magnesium,

there are several different marine alloys. Some are for plate work, others for rivets and castings. All must resist corrosion and all must be readily workable. In the case of aluminum, even the best alloys are somewhat susceptible to corrosion, and it is well to add a coat of marine paint wherever the metal is liable to come in contact with water. While this may seem reason enough to avoid the material, actually it is no great disadvantage when one realizes that an aluminum boat, with reasonable care, will easily last a man's lifetime.

A factor that requires careful consideration in any metal construction is that of electrolysis, a chemical reaction that may take place when two different metals come in contact with each other. Bronze and aluminum, for example, must be carefully separated by insulation, and while this is not difficult, it may be easily overlooked.

Metal boats are something that the yachtsman must become accustomed to before he can realize their advantages. They can, if desired, be made in such a manner that it is almost impossible to distinguish them from any ordinary boat. The deck and cabin must be wood or it would be painful to touch them after a few hours in the sun. As a result, these craft are not much different in appearance from ordinary ones. With good designing, furthermore, an aluminum or a steel boat can be produced that will not handle any differently from boats that are made of wood. And all the time the owner of such a vessel knows that he has a sound and a lasting hull beneath him.

Of course, one always hears arguments against metal boats. Take the aluminum canoe, for example. Put out by Grumman Aircraft, there are thousands of these "tin cans" all over the country. And there are thousands of people who claim that they are worthless because they don't handle like canoes. So they blame it on the material out of which they are made. Actually, however, these boats are not designed like canoes, and so they can hardly be expected to act like them. On the whole, the advantages of metal boats far outweigh the disadvantages.

For the yachtsman who can't possibly bring himself to like metal boats, but who still wants a solid hull that he won't forever have to repair and caulk, there is still plywood. Sheet ply has been used successfully for several years, but it is only recently that molded plywood boats have come into being. These boats form another group of pleasure craft that is fast increasing in size.

For years, the big problem with plywood has been in the glue that holds the thin layers of wood together. No matter how much improvement seemed to be made in the bonding material, it was impossible to find one that would resist water for very long. About fifteen years ago, however, the United States Plywood Company put a new material on the market. It was called "Weldwood," and it was absolutely impervious to the effects of water. Since then, tremendous amounts of "Weldwood" have been used in nearly every industry, with the shipbuilding trade profiting immensely from it.

The glue used in "Weldwood" has a phenol-formaldehyde base, which is nothing more than bakelite. But the properties of it are important, for it is because of them that plywood has become so important in boats.

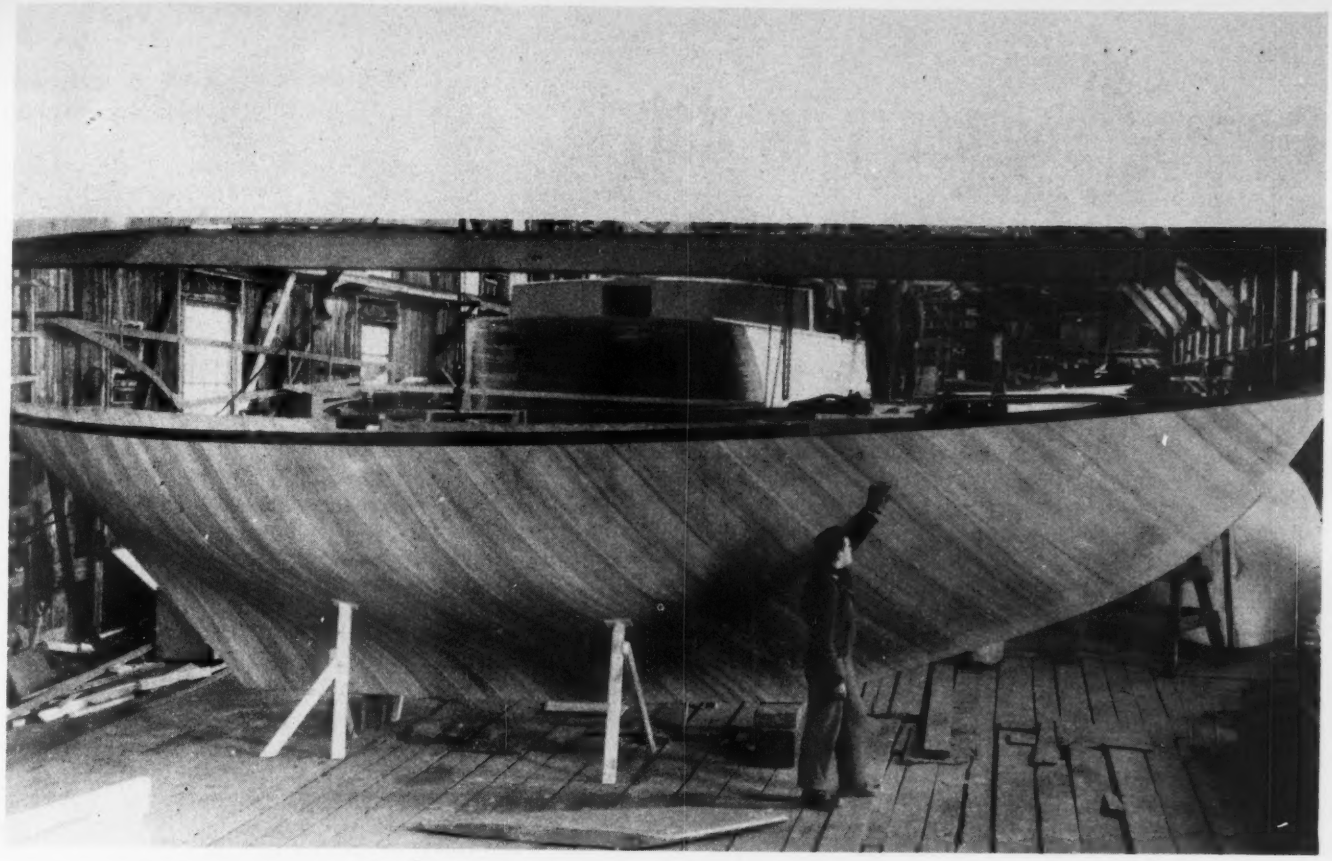
Bakelite has the unique property that once it has been formed, it cannot separate, nor can it be changed into anything else. It is unaffected by heat, acid, electrolysis, and compression, as well as water, and yet it can be worked as easily as ordinary wood. In boats, it does not shrink or swell to any great degree, and it is rotproof and nearly non-splitting. As for strength, it is said that "Weldwood" is the strongest material per unit weight ever devised.

Well, this sounds like pretty terrific stuff. Isn't there anything wrong with it? Yes, there is — cost. Marine plywood requires time and skill to produce, and the resulting price is somewhat high. But it is not prohibitive, and a large number of boats are made entirely of it.

"Weldwood" is made up of a number of thin sheets of wood, with the grain running in different directions. Between each layer of the wood, as it is being made, is placed a thin sheet of bakelite in "suspended animation." The whole thing, when put together, is placed in a large bag of rubber, and the air is exhausted from the bag. Next, the bag and its contents are placed in a huge press, and the plywood is subjected to seventy-five pounds of pressure per square inch, at a temperature of three hundred degrees Fahrenheit. When the plywood is removed from the press, it is ready for use. Molded boats are built in the same manner, except that the press is in the shape of the boat. The enormous initial cost of this mold is one reason why there are so few boats built in this manner.

The largest molded plywood boat to date seems to be the L-24, a thirty-eight foot, three inch sailboat made by the Luders Marine Construction Company.

"New materials assure the boat owner of a sound vessel."



Shown under construction at the Luders Marine Construction Co. is the shell of a molded plywood boat.

This is really going some when one considers the size of the press that must be used. As for sheet plywood, lengths up to fifty feet are stocked (these are nine feet wide), and during the war eighty-five foot pieces were produced for use in the famous PT boats.

Hulls of plywood, whether sheet or molded, have great strength, and require very little if any interior framework. When well built, they are absolutely leakproof. They have the added advantage of lightness and consequent extra speed, while differing from planked boats very little in regards to handling.

Even in the older types of boats, it is difficult to find one that does not have any plywood in her construction, for the material is invaluable in cabins and interior woodwork. Most of the metal boats have plywood cabins, decks, or interiors. It is another material that is racing with metal for popularity.

The most interesting, while not the most important new material in boats is Fiberglass, the representative of the plastics industry. With this substance, not only can the whole hull of a boat be molded, but the entire vessel, decks, splash rails, coamings, mast steps, centerboard trunks, and motor mounts, may be made in one piece. The process of building a boat of Fiberglass does not differ greatly from that employed in molded plywood craft. For many years plastics have been worthless in boatbuilding simply because of the lack of a good bonding glue. Not long ago, however, there were developed several thermo-setting resins of the polyester type, and since that time, the use of Fiberglass and other such materials has increased a great deal.

The largest single piece of plastic ever molded is the hull of a new Navy personnel-carrying motor launch, which is twenty-eight feet long. Several of these are currently in production at the Winner Manufacturing Company of West Trenton, New Jersey. The launch, constructed entirely of Fiberglass, is made in an aluminum mold set in a deep concrete pit. The hull is built up of layers of Fiberglass matting, impregnated with a resin glue. When a sufficient thickness has been built up inside the metal mold, a large rubber blimp, shaped like the inside of the boat, is fitted over the plastic, and inflated to a pressure of thirty pounds to the square inch. A large lid is then placed over the pit, and the temperature within is raised to 250 Fahrenheit degrees. After several hours of baking, the hull is removed, and it is ready for the superstructure. The use of a collapsible inner mold makes it possible to fashion almost any shape.

The advantages of a boat of this type lie in the fact that Fiberglass is far cheaper than either wood or steel, and stronger, weight for weight, than either of them. The material is, furthermore, impervious to all climatic conditions, as well as to rot, corrosion, worms, electrolysis, and the many other things that are continually causing damage to wooden boats. One of its biggest advantages, as Bill Aikens mentioned, is that Fiberglass boats do not need painting, as colors may be impregnated throughout the plastic. The owner may scrape and sand to his heart's content without fear of destroying the finish.

There are many fallacies connected with plastic boats. For the information of those who may think that these craft burn easily, or tend to melt under a hot sun, it might be explained that the yachtsman can rest assured that he is entirely safe aboard a plastic boat.

With all these new improvements flooding the market, it would seem that all of the older boats should be deserted immediately, in favor of steel, plywood, and molded glue. But it takes a long time for any new thing to replace an old one, especially if the latter has become as strongly entrenched in its position as have wooden boats. And it takes time for these improvements to be thoroughly tested, used, and placed on the market for general distribution. Then, too, while one can purchase these new boats today, without much difficulty, the materials out of which they are built are still very much in the experimental state. We will see wooden boats around for a while yet.

training engineers in italy

By Giuseppe Tardini

An F. S. S. P. Tells of His Own School

I have been asked to give you some information about technical teaching and the preparation of engineers in Italy. There are many questions involved, and I am afraid it will be pretty difficult for me to make myself understood, as our Italian educational system differs widely from the American, and the same terms do not have the same meaning in Italy and in the United States. Well, let us try!

Our institutes of technology grant a single academic degree after five years of study. The academic year is not divided in terms, but consists of one single term of about seven months; three more months are taken by the examinations. Our classes are very large and this fact creates most of the difficulties for the students as well as for the staff and the administration.

This situation depends from the fact that our schools are considered public and a student who has achieved certain standards and wants to enter a certain school cannot be refused admission on the basis that the number of applications is too large. The schools ought to increase their staff and facilities according to the number of students, but their budget is usually not in a state to allow that, and even if it were, all that can be done only by small steps. Tuitions and fees are very low and cannot be increased, for social reasons. The Politecnico of Milan, the school that I know best, tries to keep the number of students as low as possible, by raising every year the difficulty of the studies, in order to discourage the less efficient students, but this results practically only in transferring many students from Milan to other schools (about 700 left this Politecnico last fall), and owing to the large number of new applications certainly does not solve the problem. The number of registered students at the Politecnico of Milan in 1937 was about 1,400 and reached in 1947 the number of 6,000. The teaching staff in the same years was increased from about 100 to about 400, that is, we have now about 1 member of the teaching staff to every 15 students; this ratio at M. I. T. is about 1 to 4.

We are well aware of the disadvantages of this situation and are discussing and adopting every possible means to improve it for the future.

For the equipment the situation is perhaps still worse. I may say that our equipment for research and teaching was fairly good and up to date till 1936. Since that time, owing to many obvious international and economic difficulties, not much has been made to improve our equipment, which remained completely static during the last years. Add to this, that during the war most of our equipment had to be hidden underground and part of it, especially the most delicate instruments, has suffered from that.

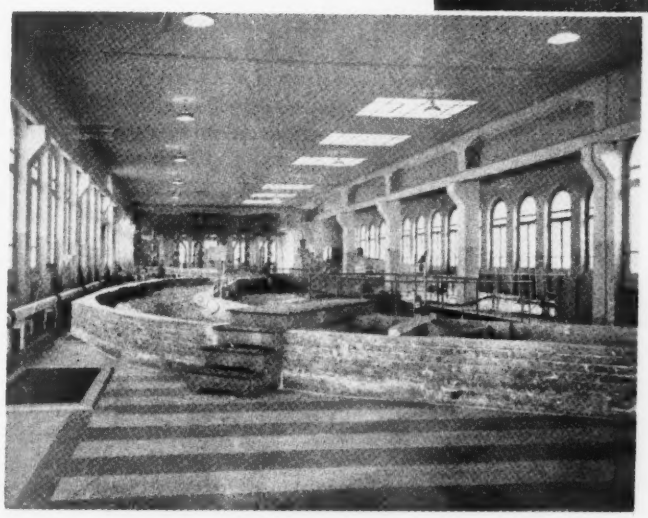
Our allowances are very poor and we concentrate now especially in catching up with the foreign literature, buying little by little books and reviews published during the last years, which we did not get. It is the cheapest way, and therefore the only way for us at present, to keep abreast with technical progress, and we are devoting to this task most of our resources and the time that remains free from teaching and instructing. In spite of all that, we are preparing some projects, hoping that some day we will find the money necessary to carry them to a conclusion.

Perhaps what we did during the war is of interest. Teaching and research work were terribly reduced owing to the lack of staff and of students, who were serving in the armed forces. The diagram of students per year refers to registered students and therefore does not show the phenomenon in its practical reality, because during the war most students were registered by their parents or ex-officio during their absence. The number of students actually present at school during the academic years 1941 till 1945 was a small percentage of those registered. Equipment, as I pointed out, had to be removed in order to avoid the risks of war; new equipment could not be purchased. The Administration of the School did the possible, and the impossible, to help students who were working in the "Underground" and various members of the staff were active members of these organizations.

A laboratory of the Electrical Engineering Department at the Politecnico of Milan.

Entrance to the E. E. building at the Milan school.

A room in the hydraulics lab of the Politecnico.



After the war thousands of students came back to end their studies. Even last year I have many reasons to suppose that more than 50% of the students at the Politecnico of Milan was formed by veterans or, anyway by students who had interrupted their studies for some years because of the war. Our educational system requires a final oral examination for every course at the end of every academic year, and this job, owing to the large classes we have, absorbs a lot of time.

In a few words, we have too many students and too little money.

That is perhaps one of the reasons why our teaching has to be developed more theoretically and, in comparison with the American student, the Italian student gets from the school more theory and general ideas than practical applications. We think that the best thing that can be done at present is to give to our engineer the widest basis on which to work when he will enter the profession, without trying to give him a specialization for which we are not equipped.

In our plan of study the first two years are almost completely taken by mathematical and pure scientific subjects; the last three years are devoted to the technical subjects, and it is during these three years that the student has to choose his branch. Our school offers six different branches: three for civil engineers and three for industrial engineers, but a large number of subjects are common to all branches, so that the differentation between different branches is not as deep as it is in other countries, including United States. As an average the Italian engineering student spends in the school every week about 18 hours for classes (usually in the morning) and 16 hours for applications (usually in the afternoon). Most "applications" are numerical or graphical and only a few take place in laboratories; as a consequence of that, classes are almost exclusively theoretical and the professor does not develop problems and numerical examples, leaving this work to the afternoon exercises and home work. The size of classes, which reaches sometimes 300 pupils, renders the asking of questions impossible during lessons. Quizzes are given during the academic year in many subjects, but the most important element for judging a student is usually the final examination in every subject, which for some subjects is accompanied by the preparation of a design.

At the end of the five years, the student who has passed all examinations has to discuss his thesis work (usually the design of a plant or part of it, or a theoretical research, very seldom experimental) with a commission of the members of the faculty.

There are many complaints against this address of the technical studies, and as a matter of fact I think that, if our Politecnico certainly offers a good preparation for the best pupils, it fails perhaps to form a useful average engineer as required for most jobs.

There are also many proposals to modify all that, but evidently it is not only a matter of changing or retouching the programs, but it involves deep changes, that, as far as now, do not appear as possible.

I spoke about the Politecnico of Milan, my school, which, by the way, can probably be considered as the best school for engineering in Italy, or at least as one of the two or three best schools, but all that I said can be applied to all our technical schools. We will probably never be able to dispose of the enormous means that your school [M. I. T.] possesses, but still we hope that our work in the future will not be completely useless to mankind, and we are striving to reach in some years (how long will it take?) the place that our country held once with honor and dignity in the development of science and technology.

education

By Londiniensis

A Discussion of Methods

It might be useful to indicate how and why this article came to be written, as it will be apparent, on further reading, that the author knows little or nothing of the subject and is really one who is still very much involved in the process of being educated. In the course of last year's Foreign Student Summer Project, two F. S. S. P.'s were invited to dinner by a member of the organizing committee. The party comprised four girls, two American men, a Parisian and a Londoner. How the party was expected to continue after dinner is not known, but what did happen was that, for more than an hour, eight young people discussed education, its aims, and the pattern followed in England, France, and the U. S. A. Some days later, the Londoner was asked by his host to write something on this subject. Thence, after much badgering and reminding, the present article. In view of the author's paucity of knowledge and experience in the field, he will merely attempt to pose some of the questions which the eight discussed in the hope that they may give some food for thought to any who are prepared to think objectively.

On thinking back, three main points come to mind. Firstly, what is the aim of education? This can only be answered in very general terms, since different authorities have diverging ideas on the subject. Most people would probably agree that one of the primary purposes of education is to fit a person to take an active part in the life of the community in which he lives. However, what is meant by "an active part"? The first essential is, of course, that one should be in a position to earn a living and support such others as are dependent upon one. This can be done, in certain occupations, by complete illiterates, but we are here concerned with those jobs which require a certain amount of special training over and above the three R's. Assuming that a person can maintain himself and, if necessary, his family, what else is required? In our so-called democratic way of life we are expected to participate in some way in the government of our community and country. This presupposes, often quite wrongly, that we are capable of deciding for ourselves what is the best policy for us, and also what is the best way to get on with our international neighbours. It is obvious that, in order to make any intelligent contribution to government, both local and national, we must have a certain minimum knowledge of home and foreign events and also an ability to appraise and use such knowledge of home and foreign events and also an ability to appraise and use such knowledge when shaping our own ideas. One other requirement is a facility for understanding the other fellow's point of view. This is something which is very necessary to us in our daily lives and in our personal contacts with friends, business associates, and "the man in the street." A person, who, generally speaking, cannot get on amicably with his fellow beings can hardly be said to be educated.

The ideas put forward so far are probably acceptable to most readers and it is not proposed to introduce any more of a perhaps controversial nature, and so get away from the theme of this article. Let us assume then, that if a person is capable of taking "an active part" in his community, as defined above, he is at least partially educated. The next point is: How do the educational authorities tackle their part of the job and are they going the right way about it? It is here emphasized that "formal" education is only part of the whole, and that other factors, such as family life, hobbies, etc., have just as important a contribution to make to the process of education. Actually, to attempt to answer this question fully is beyond the author's ability and would involve pages of discussion far beyond the scope of this brief note. However, as this is written for one of the M. I. T. publications it might not be out of place to note a few of the writer's first impressions of American college education as seen from one summer session in Cambridge. These impressions will be given in the form of questions which it is hoped the reader will answer for himself. Is not the system of weekly "quizzes" and marked homework or preparation very reminiscent of elementary school days and is it not a form of spoon-feeding the student? Is not the system of restricted self-contained courses a narrowing influence on the student's mind? Is the idea of working through a textbook for a given course a good one?

In order to explain why these questions come to the author's mind, a word or two about the British system of higher education might be appropriate here. The reason for this is solely to invite comparison and is not an attempt to favor one system or the other. Up until the age of about sixteen years the formal education of those who are going to college is basically the same in both countries, although there are differences in detail and it seems fairly definite that for a given age the British youngster is academically ahead of his American counterpart. In Britain, between the ages of sixteen and eighteen, the student goes through what might be called a transition period in the upper sixth forms of the secondary school. During this period he begins to specialize and is encouraged by his teachers to develop an independent, critical, and ever widening outlook on both his work and his life in general. The development of the mind is at least equal in importance to the acquisition of a field of basic knowledge for his university career. When the young student enters the university the metamorphosis should be nearly complete. He is then an independent individual who carries the larger share of the responsibility for his education. He has tutors and friends to help and give advice when called upon, but he is responsible to himself for attending lectures, submitting work for approval and for arranging his studies in preparation for the final examination at the end of three, or perhaps four, years. In addition to academic study, there is every encouragement to take part in social and extracurricular activities. The combination of all these produces, in most cases, a mature individual with a fairly balanced outlook. With regard to the emphasis on outside activities, the situation at the M. I. T. and other American colleges seems to be very similar.

Consider academic study for a moment. Surely this should not be a mere acquisition of facts, but rather a combination of gaining knowledge with the simultaneous development of an inquisitive and logical

The South West Essex Technical College and School of Art.

mind. Too often the hard job of learning is made into an endless drudge by uninspired teachers who slavishly follow the text and are unable to appreciate the student's ideas on the subject. Readers who have suffered thus, long and patiently, may be interested in an article, in the January issue of the *American Journal of Physics*, on the teaching of the scientific method. The question of imaginative teaching is the responsibility of the educational authorities and so also is the choice of subjects for the study demanded of an undergraduate. It is here that, in the past, some "technical institutions" have concerned themselves with technical studies and have not insisted on a broad basis of learning for the student. In these days students, especially technical and scientific students, have to specialize a great deal. It is good to note that the dangers of developing too narrow an outlook have been recognized and that most colleges now insist upon a minimum leavening of cultural studies. Once again, though, it requires an enlightened teaching staff to persuade a student who is interested only in his technical studies to derive any benefit from the "compulsories."

The third main question is this: Having got to the stage of being a university student, what is our own attitude towards our stay in a college community? Some of us are thinking only of the qualifications which we hope to obtain and the subsequent comfortable income attached to them. Is this a healthy attitude of mind? A large portion of our lives is going to be spent in activities to which our technical training has no apparent relation. Should we not then pay some attention to those "other things"? There is hardly a better place in which to learn how to run our lives than the university, provided that we are given sufficient responsibility. Some of us are here with the idea of having a jolly good time while we can and be hanged to work and all that. This manner of thinking shows, among other things, a complete disregard of our obligations to others and need not be commented on here. Our own attitude to a university career depends very largely upon our education previous to coming up. Here is meant education in the wider sense, embracing the influence not only of school and learning but also of our family life and friends and the environment in which we have grown up. These latter are almost solely responsible for molding our characters and giving us those finer qualities over which we have little or no control and which are not directly the concern of the educational authorities. They are things which are the true hallmark of responsible citizens. However, a suitable atmosphere in the communal life of the university can do much to make up for deficiencies in this direction and so indirectly lay the foundations of better chances for future generations. This is a further argument for a college life which exceeds the narrow confines of academic study.

Having left college and gone into the world, what is our attitude to what we have accomplished and what we have yet to do? How do we compare ourselves to those who have not had the chance which we have had? Do we look upon ourselves as little tin-pot experts who know all there is to know about something which we have studied for a short while at college and that other people do not know what they are talking about? Do we think that we have nothing else to learn? One does not often meet with a person who thinks along these lines, but there are many who act as if they do. For such people it would seem that the process of education is not complete. Humility should be one of the qualities possessed by an educated and therefore cultured person. University life has not finished its job if a student leaves college with any illusions about his own worth and place in the social system. A graduate's attitude should be that of a person who has been granted a privilege, *i.e.*, a college education, and by virtue thereof has an obligation to society to prove his worth.

In the above discussion the author has been concerned solely with the education of university students and has not attempted to consider at all the vast majority of people who get no further academically than secondary or high school. Many of these have no need of academic teaching, but the "other side" of life at college would be of great value to them, and ultimately to the nation.

It is appreciated that this has been a somewhat confused and rambling article and it is submitted only in the hope that it may, at least, serve to ask some questions in the reader's mind. It should be fairly easy to judge from it the feelings of that small international after-dinner party, as it touches on most of the topics there discussed. As a parting thought, would it not be a good thing if all women could have the advantages of higher education, in view of the supremely important positions they hold as mothers of families? The mere male is comparatively unimportant in the domestic world.

chlorine's sister grows up

By William R. Lucas, '51, and Kenneth Kopple, '51

A Few Facts on Fluorine and Its Handling

As I climbed to the fourth floor of building six, I expected a long-winded lecture replete with calculations, equations, and charts. I had been led to believe that graduate students could dish such stuff out, and, by interviewing one on the properties of fluorine, I was "asking for it."

Most people are familiar with the fact that fluorine is not only dangerous but useful. Interested, I wanted a simple, concise explanation of its properties. After I had explained my purpose, I was obliged with the most interesting interview in which I have ever taken part.

The laboratory I entered centered around an electrolytic cell encased in a water bath surrounded by asbestos. The cell contained a mixture of potassium acid fluoride and hydrogen fluoride, liquid at one hundred degrees Centigrade. Carbon and nickel served as the electrodes and the fluorine was collected in a copper trap. Scattered around the lab were quantities of glass which showed the effects of the gas generated in the cell — they had been literally chewed to bits.

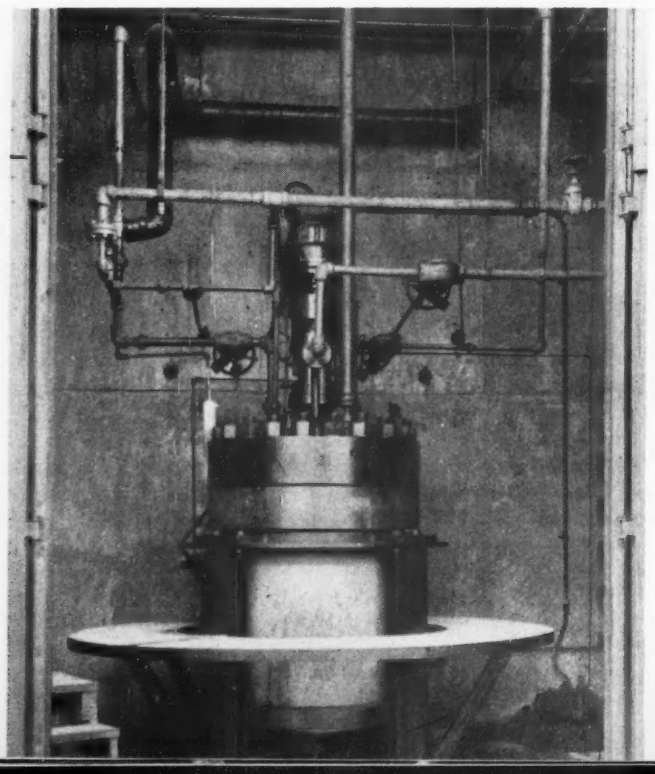
At the time of my interview, research being done in this laboratory included a study of a fluorine compound known as iodine heptafluoride, IF_7, as a possible fluorinating agent and means of transporting fluorine. IF_7 is produced by reacting iodine with fluorine, forming iodine pentafluoride, which can be oxidized by further heat and excess fluorine. To give emphasis to our discussion, my informant asked if I would like to smell the vapors of his pet product. I showed my eagerness and gasped in amazement at the queerest olfactory sensation I have yet experienced; the odor didn't fit into any category.

I soon became acquainted with the degree of fluorine's activity. The electrolytic generator was switched on; when it was "perking," the researcher opened a small escape valve and directed a stream of illuminating gas into the escaping halogen. The gas immediately ignited. Next came a "two-by-four" block of wood and a piece of rubber, both of which caught fire in the fluorine. Looking for another "victim," the chemist espied a dangling piece of shade cord and placed it in the stream. Five . . . ten . . . fifteen seconds and nothing happened. Somewhat curious, he tried again, fraying the cord and holding it even longer in the jet. Still the cord floated lazily in the gas. Finally, he jokingly said that he's record the fact and investigate.

By this time I was ready to ask the expected question. "Is anything unaffected by fluorine?" There are a few substances, it seemed. Nitrogen, for example, is quite unreactive, and so also are fluorinated hydrocarbons, these being only sluggishly attacked even when not completely substituted with fluorine. Thus, except for inorganic fluorine compounds, there isn't much which can be used in the handling of fluorine without some ill effect.

Such a picture greeted workers in the field of fluorine chemistry not too long ago, when fluorine became of such immense importance, but with the impetus given by the war, methods of mass producing the element, storing it under pressure, and utilizing it in compounds with unusual properties were developed. Uranium hexafluoride, for example, was used in separating the isotopes of uranium; sulfur hexafluoride has been utilized as an insulating gas in the Van de Graaff generator here at Tech; a hydrogen-fluorine torch was developed; fluorinated hydrocarbons are yielding chemically resistant plastics and lubricants; and fluorine compounds in general are stretching the field of investigation of physical chemistry.

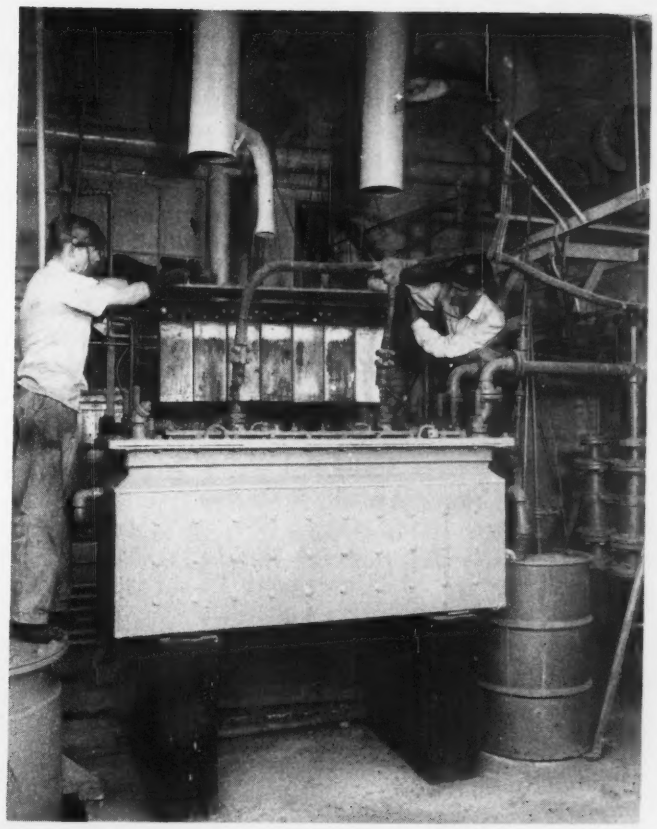
Isolated at the end of the nineteenth century by Moissan, fluorine is the most electronegative element known. Although it is a member of the halogen family, being the lightest of the four elements, the use of



One of a number of 110-gallon autoclaves used for producing organic fluorine compounds at the Hooker Electrochemical Co.

Using electrodes of nickel or graphite such electrolytic cells as this are now producing fluorine on a commercial scale.

Courtesy Hooker Electrochemical Co.



Metal goes up in smoke as pure fluorine is run into a light steel tube. The tube was heated slightly at the end.

Courtesy Pennsalt

analogy to the other halogens in order to predict its properties often leads to error. It forms compounds with all but the inert gases, usually with the other elements in their highest valence state, as for example, in iodine heptafluoride. Inorganic fluorides often have much lower melting and boiling points than corresponding compounds with other halides. For example, the fluorine torch is self-fluxing when used with copper, since the copper fluoride first formed melts lower than the copper metal itself. Hydrogen fluoride, in the liquid state, is a good ionizing solvent, just as water or liquid ammonia, which are the hydrides of fluorine's immediate neighbors in the periodic table. Inorganic fluorides often crystallize with hydrogen fluoride of crystallization.

The fluorocarbons, compounds of fluorine and carbon, have great internal stability and resistance to chemical action. Since they don't burn and are stable even to alkali metals at high temperatures, they are expected to find use in heat transfer systems, as high temperature lubricants and turbine impellants. An interesting sidelight on the stability of these compounds is the fact that carbon tetrafluoride has an ionization potential higher than that of argon. As exemplified by the use to which sulfur hexafluoride has been put, organic fluorine compounds also have high dielectric strength.

The toxicity of organic fluoro compounds is also of interest. Although sodium fluoride has been used as an insecticide and its poisonous properties ascribed to the fluoride ion, fluoracetic acid, which produces no fluoride ion, is even more efficient as an insecticide while chloracetic acid has no comparable effect.

The chemical groups, trifluoromethyl and difluoromethylene, have been found to impart stability to organic molecules and are being incorporated into dyes to improve stability and fastness.

Fluorine is not a scarce element on the earth's surface, being more abundant on land than chlorine and as plentiful as nitrogen or carbon. Until recently, its scarcity has been due to the difficulty occurring in its preparation and handling. Before fluorine could become available in commercial quantities, these difficulties had to be overcome.

Since fluorine attacks almost every metal at high rates, the use of metals in handling fluorine resolves itself into the problem of finding those which corrode least readily. Much of fluorine research has been along these lines. It has been found that nickel is the least attacked of the common metals, one set of tests revealing that, at 400 degrees, in an atmosphere of pure fluorine, it corrodes at a rate of only 0.0007 of an inch per month, a low value when compared to copper which disappears at the rate of 0.16 inch each month under identical conditions. At higher temperatures, the speeds increase until, at 700 degrees, nickel goes at 0.034 inch per month and copper at 2.9 inches per month. Two alloys, Monel and Inconel, have also been found to be of service in working with fluorine, monel being slightly less attacked than nickel at lower temperatures. Surprisingly enough, under the conditions of the test, 2S aluminum, which is almost the pure metal, and useless because of mechanical considera-

(*Continued on page 28*)

fields, curves, and particles

By Alfred A. Kraus, Jr., '49

A Survey of Mass Spectroscopy

In our study of chemistry we observe that most of the lighter elements have atomic weights that are nearly whole numbers when oxygen is taken to be exactly 16. These approximations are called atomic mass numbers. Table I gives values for some of the light elements.

TABLE I

SOME ATOMIC WEIGHTS

Element	*Symbol*	*Atomic Weight*	*Atomic Mass No.*
Hydrogen	H	1.0081	1
Helium	He	4.003	4
Carbon	C	12.010	12
Nitrogen	N	14.008	14
Oxygen	O	16.0000	16
Neon	Ne	20.183	20
Sodium	Na	22.997	23
Aluminum	Al	26.97	27
Sulphur	S	32.06	32
Chlorine	Cl	35.457	—

Early workers recognized that the atomic weight of chlorine was not approximated by a whole number. This difficulty was explained when it was discovered that the element was composed of two kinds of atoms, with identical chemical properties but different atomic weights. About three-fourths of ordinary chlorine has atomic mass 35; the other quarter has mass number 37. Such atoms of similar chemistry but different masses are called isotopes.

For example, ordinary uranium is composed of 0.72% U^{235}, and the remaining 99.28% is U^{238} (the superscript indicates the atomic mass number). Since U^{235} is used in one type of atomic bomb, finding a means of separating it from the less fissionable U^{238} was a major problem of the Manhattan Project.

In general, isotopes can be separated by a chemical means or by some physical process of a non-electrical nature. As an example of the later method, heavy hydrogen, known as deuterium, can be separated from ordinary hydrogen because of a difference in the vapor pressures of the two substances. However, in the cases of chlorine or uranium, the weights of the isotopes differ from each other by such a small percentage that these separations are not complete enough. However, by means of instruments called mass spectrometers, these heavier elements can be separated. In addition, atomic weights and relative abundances of the isotopes can be quite accurately determined. In the case of chlorine, 75.4% of it is of isotopic weight 34.97884, while the remaining 24.6% has isotopic weight of 36.97770. In these figures, we see what mass spectroscopy can do.

Historically the instruments were developed along two main lines. In general, spectrometers consist of (1) a source of ions of the atoms to be studied, (2) an electric and magnetic system to deflect the beam of charged particles into separate beams according to mass, and (3) a photographic plate or some other means of observing the deflections. The essential difference between the two main types is that in the earlier instruments the deflecting fields were parallel to each other and perpendicular to the initial ion path. But in the later instruments both of the fields and the ion path are all mutually perpendicular. There are some instruments that do not fall into these general categories.

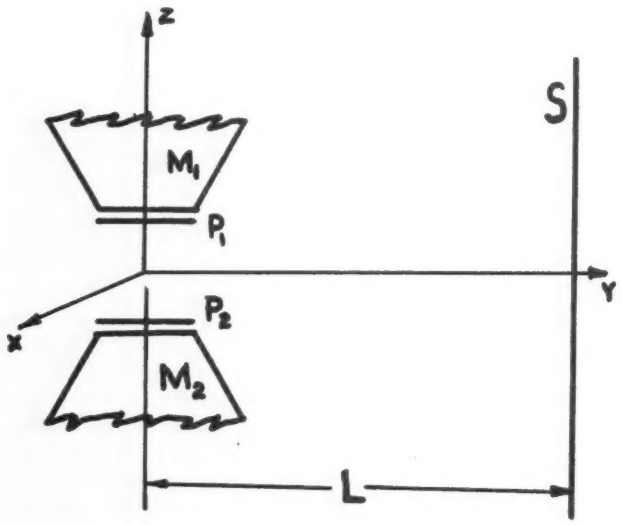


Figure 1. Thomson's spectrograph.

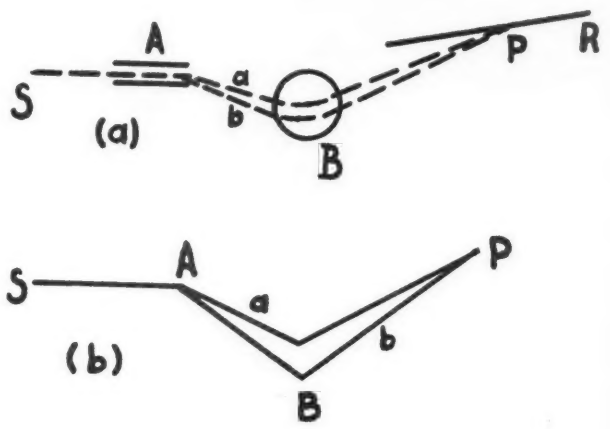


Figure 2. Aston's velocity focusing.

For example, Smythe and Mattauch developed one that had no magnetic field. In addition to these generalizations, one should know that mass spectrometers measure only the charge to mass ratio of the particles. But the elementary charge is assumed to be the same for all ions. Then comparison is made with oxygen as 16.0000 atomic mass units, so that the determination of mass is independent of the charge.

With the first mass spectrograph he made, J. J. Thomson measured the charge to mass ratio of canal rays, beams of charged particles that pass through holes in the cathode of a gas discharge tube. A diagram of the instrument is shown in figure 1. The beam of rays enters the system from a gas discharge located on the y axis to the left of the origin. The velocities of the particles in the beam is random, but for any one particle let it be V_0. The remainder of the apparatus is the two magnet poles M_1 and M_2, the two plates, P_1 and P_2, and finally a photographic plate, S, perpendicular to the y axis. The magnet produces a field of intensity B, while the voltage across the plates produces an electric field of magnitude E. The direction of both of these fields is parallel to the z axis.

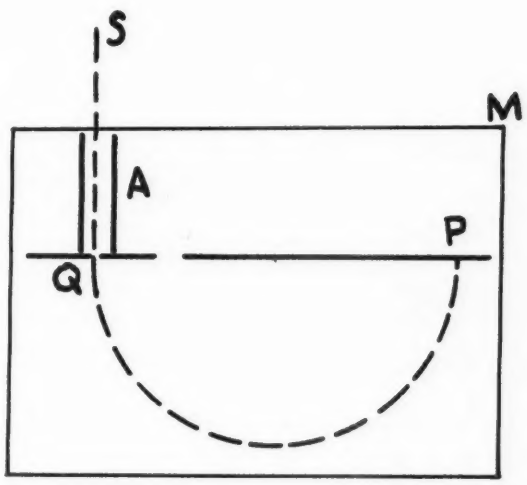


Figure 3. Bainbridge's Method.

The magnetic force on the particle is

$$F = q(v \times B) = qV_0B = m\frac{d^2x}{dt^2},$$

since the force is perpendicular to both the velocity and magnetic induction vectors. Integrating this equation with respect to time we have

$$V_x = \frac{q}{m}V_0Bt_m,$$

where t_m is the time the particle is acted on by the force. If the effective length of the field of B is l_m,

$$t_m = l_m/V_0$$

If the angular deflection is small so that the velocity along the y axis is not changed appreciably, we have

$$V_x = \frac{q}{m}Bl_m$$

for the velocity of the particle as it comes out of the magnetic field. Similarly, since

$$F = qE = m\frac{d^2z}{dt^2}$$

for the electrical deflection,

$$V_z = \frac{q}{m}E\frac{l_e}{V_0},$$

where l_e is the effective length of the electric field. If we now consider $L>>l_e$ and $L>>l_m$, we can neglect the displacements of the particles in the fields compared to the final displacements. The time it takes the particles to travel to the screen is

$$t_0 = L/V_0.$$

Then since the space is field free, there are no forces (the gravitational force is so small we neglect it). Then the beam hits the screen at

$$x = V_xt_0 = \frac{q}{m}Bl_m\left(\frac{L}{V_0}\right), \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$y = L,$$

$$z = V_zt_0 = \frac{q}{m}E\frac{l_eL}{V_0^2}. \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Thus we see that for each velocity, the particle will hit the screen at a different point. If we solve equation (1) and (2) for V_0^2,

$$V_0^2 = B^2\frac{L^2l_m^2}{x^2}\left(\frac{q}{m}\right)^2 = E\frac{Ll_e}{z}\left(\frac{q}{m}\right).$$

From these we get

$$z = \left[\frac{El_e}{qB^2Ll_m}\right]mx^2 = (\text{constant})\,x^2, \quad \ldots\ldots\ldots\ldots (3)$$

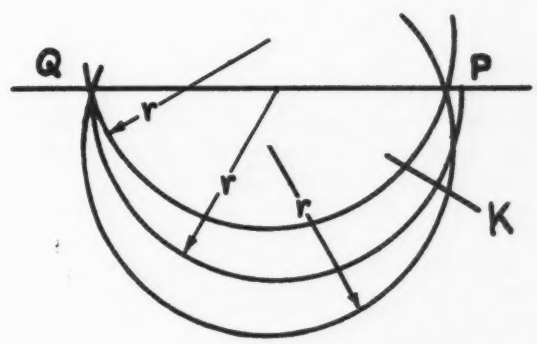


Figure 4. The focusing effect in Bainbridge's spectrograph.

the equation of a parabola. But the deflections are in just one quadrant, that is, where $x>0$ and $z>0$. If E is reversed, the other half of the parabola will appear. This procedure makes the calculation of the constant more accurate. With the constant and other parameters known. the charge to mass ratio can be determined.

Thomson found parabolas due to O_2^+, H_2^+, and CO^+. These are normal molecules with one electron "knocked off." In addition he found parabolas for H^+ and O^+. When neon was studied, traces for mass numbers 20 and 22 were found. This discovery indicated that neon had isotopes 20 and 22.

By studying equation (3) we see that if a particle were double charged it would appear to have half of its mass. As an example, D^+ and He^{++} would appear as the same curve. But the mass of He^{++} is not exactly twice that of D^+. Lukanow and Schutze have made a Thomson spectrograph that will resolve these two traces very well. Their instrument is probably the most accurate of the first type.

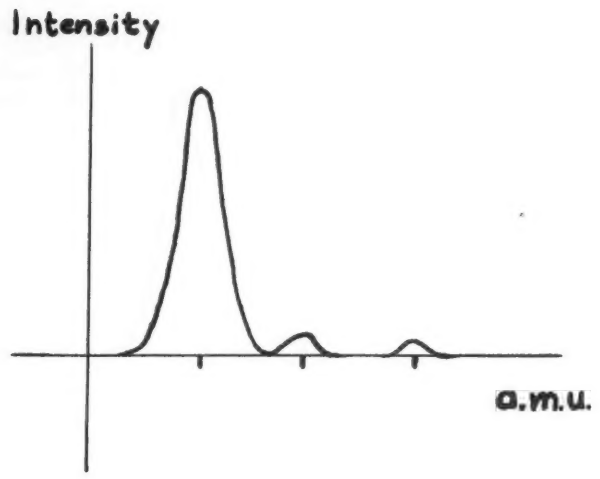


Figure 6. A typical result for Si.

However the second type, with the two fields and the initial beam all mutually perpendicular, is usually more accurate. With this configuration of fields, the instrument can be made to "focus" the beam to a point instead of spreading it out into a parabola. In this manner we can get a more intense indication and thus detect less plentiful isotopes. This process is known as first order focusing or velocity focusing.

One of Aston's early instruments is shown simply in figure 2a. The ions come from a source S and are deflected by an electric field between the plates A. From equation (2) we see that the faster particles are deflected less than the slower ones. Then at B a magnetic field directed into the paper deflects the particles in the opposite direction; again the faster particles are deflected less, as we see from equation (1). The result is that the ions of a given mass converge to a point P. This result is more simply shown in figure 2b. The path of a faster particle is marked a. With proper design, the instrument will focus particles of different masses nearly on a line so that a photographic plate, R, can be used as shown in figure 2a to get the relative measurement.

Bainbridge eliminated the velocity difficulty by using a "velocity filter," that is, a device that allows particles of only one velocity to pass through it. The instrument is shown diagrammatically in figure 3. Again B is directed into the paper in the area M. The ions come from a source S. A force of magnitude qvB is directed at 90° to the direction of motion while the particles are in M. However, between the plates A, an electric field is adjusted so that the electric force is just opposite the magnetic force. For this case,

$$qvB = qE.$$

The velocity of the particles then is independent of mass and numerically equal to

$$v = E/B.$$

Ions with any other velocity have a net force not equal to zero. They are then deflected toward one of the plates and fail to pass through the slit Q. Those that go through Q travel in a circular path. The centrifugal force is

$$Fr = \frac{mv^2}{r} = qvB.$$

Solving this equation for r,

$$v = \left[\frac{v}{qB}\right]m. \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

If the particles are allowed to travel through 180° of the arc of the circle, a second focusing effect is obtained. Suppose the ions come into the region below Q with a small transverse component of velocity. In the actual instrument this dispersion is very small, on the order of a degree. But in order to emphasize the focusing effect, in figure 4 the dispersion is made greater. We see that at P the beam is narrower than it is anywhere else on the path, say at K for instance. This focusing of the dispersion is called second order focusing. Going back to equation 4, we see that the distance between Q and P is

$$d = 2r = \left(\frac{Qv_0}{qB}\right)m.$$

Now if P is a photographic plate, the film will record the mass spectrum of the element being investigated. Figure 5 shows a typical result.

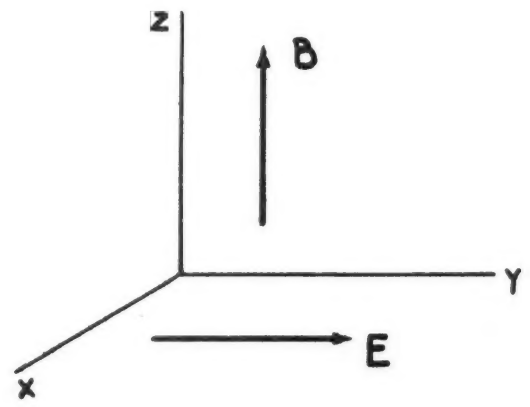


Figure 7. Cycloidal motions.

A generalized treatment of deflection systems of the second type is given by Mattauch. In this paper the more advanced spectrographs of Dempster and of Bainbridge and Jordan are given as special cases of the general theory.

Before we leave the subject of constant magnetic field focusing, we should mention Dempster's first mass spectrometer. It was quite similar to Bainbridge's except that the initial velocity is varied by another means. Then at some point on P an ion collector is placed. Then since r is fixed, by equation 4 we have

$$m = (rqB)\frac{1}{v_0}$$

In order to vary v_0, the accelerating voltage V_a is varied. Then since

$$V_0 \sim \sqrt{V_a},\ m \sim \frac{1}{\sqrt{V_a}}. \quad \ldots\ldots\ldots\ldots (5)$$

As mentioned earlier, other methods of focusing have been found. For example, Siegbahn and Svartholm found that by using a magnetic field that falls off as $r^{-\frac{1}{2}}$, two second order focusing effects are obtained. Not only are the particles focused exactly at a point P in figure 4, but also any dispersion in the direction perpendicular to the plane of the paper is also focused at another point. They further found that if the angle of travel was $\pi\sqrt{2}$, rather than just π, the two focusing

points are identical! This system then has two second order focusing properties. One must emphasize that the second order focusing principle is extremely important in obtaining high accuracies.

Perhaps at this point we should mention the precision obtained with mass spectrometers. The instruments are given two ratings, resolving power and accuracy. The former is defined as $\Delta M/M$, where M is the mass being measured, and ΔM is the difference between two masses that can be completely separated. Notice that this definition is more stringent than the optical term. The latter rating has to do with the accuracy to which the position of a peak can be determined. Let us use these definitions in an example. In figure 6 we have a typical indication. It may be the intensity of the ion current as a function of V_a (equation 5) or the darkness of a photographic plate. Since the intensity goes to zero between the peaks A and B, the instrument resolves the two masses. Suppose the peak A is $27.987 \pm .003$; the accuracy is

$$\frac{.003}{27.987} = \frac{1}{9329},$$

or approximately $1{:}10^4$. However the resolving power is merely

$$\frac{\Delta M}{M} = \frac{1}{29}.$$

This value is exceptionally low compared to that for most spectrographs. Aston's instrument had a resolving power of about 1:600 and an accuracy of $1{:}10^4$. This year Nier, Roberts, and Franklin from the University of Minnesota report that their instrument has a resolving power of "several thousand" and an accuracy of $1{:}10^6$.

There is another basic principle that has been used at times. Equation (4) can be rearranged to give

$$\omega = \frac{v}{r} = \frac{qB}{m} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Since

$$\omega = 2\pi f = \frac{2\pi}{T},$$

where f is a frequency and T its period,

$$T = \frac{2\pi m}{qB}.$$

Thus in a magnetic field the time of rotation depends only on the charge and the magnetic field as well as mass. One spectrometer proposed would be a device to measure this time directly. However there are limitations on the accuracy of measuring this quantity because it is so short. Yet it is possible to use this system in a different form. If the ions enter a region parallel to the magnetic induction vector B, the motion will complete one revolution in T seconds. During this time they will travel along the B axis a distance

$$l = vT = \frac{2\pi m v_0 \cos\alpha}{qB},$$

where v_0 is the initial velocity and α is the angle between the vectors v_0 and B. Thus the distance from the source at which the ions return to the B axis is a linear function of mass. If α is made small, yet not zero, the

(*Continued on page 40*)

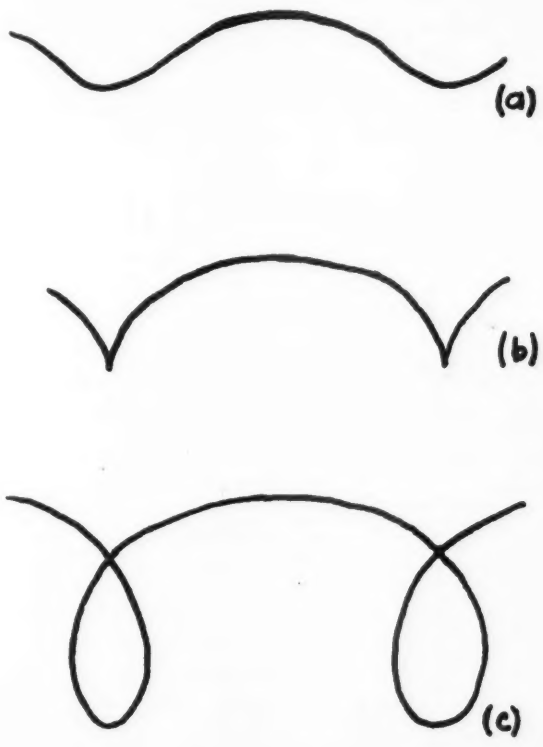
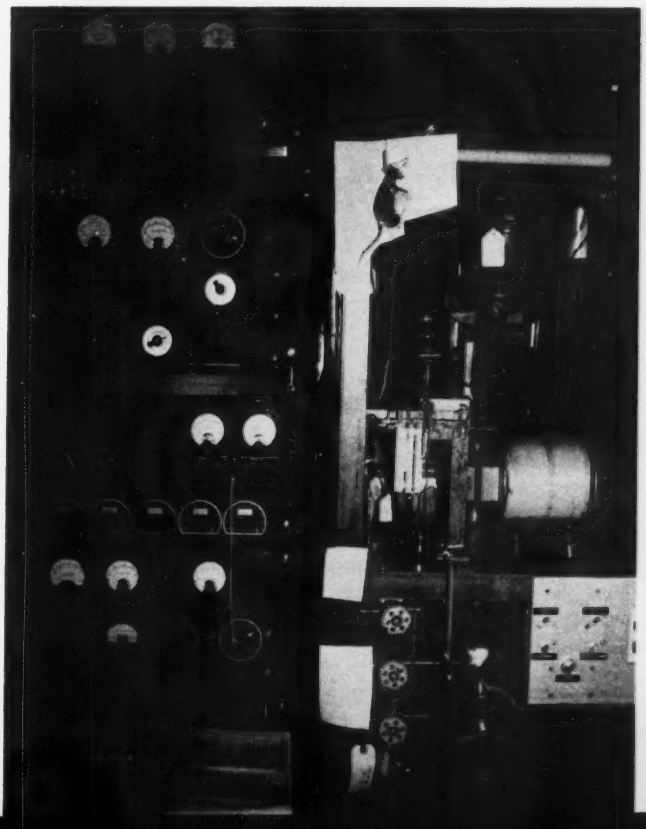


Figure 8. The field configuration for cycloidal motion of charged particles.



The mass spectrometer is much used today in biological and medical research using tracer elements.

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from the editor's notebook

Official Recognition

The convocation and inauguration are over. M. I. T. has a new president. With the installation of President Killian seems to come an official recognition of the fact that science and engineering have become a widespread business. An organization such as Tech, with study and research going on in many fields of this business, has decided that it requires an executive at its head. The choice of the new president indicates an awareness of the fact that, at the top level in research today, an administrator will do as well as, if not better than, a scientist.

Dr. Killian is not only the first M. I. T. president to be chosen as an executive without being a scientist, but he is also the first president-alumnus in the Institute's history, having graduated Course XV in 1926. It seems that the much joked about "Fifteen" boys have the last laugh.

Explanation, Information, Acclamation

This issue features two articles "which don't quite fit." The reason is *not* a paucity of material with which to fill the pages between advertisements, but a feeling that what the authors of these pieces have to say about schooling should be of interest.

Giuseppi Tardini, an Italian E. E. with considerable background in industrial research and **Londiniensis,** a British physicist interested in metallic structure, both were guests last summer of the M. I. T. Foreign Student Summer Project and wrote these articles at the request of one of F. S. S. P.'s members.

A little information about F. S. S. P. might be in order. The purpose of the organization, now in its second year of operation, is to introduce foreign graduate students to research methods and facilities here by bringing them to M. I. T. for sixteen weeks during the summer. The Institute pays their tuition and their respective governments pay travel expenses, while F. S. S. P. arranges for living facilities.

Since the aim of the project is to spread technical information abroad, only advanced graduate students are accepted; only they can get the fullest benefit from the experience. Also for this reason, applications are not accepted from displaced persons, and the participants are not encouraged to stay in the United States, but to return to their native lands where they will be most useful.

Probably one reason why F. S. S. P. works, and why it gets full coöperation from M. I. T. and the U. S. State Department is the practical manner in which it is run. There is a minimum of talk about plans for the vague future. Things are done for the present. We like this attitude; it is rather refreshing when compared to the multitude of student organizations in similar fields which bite off more than they can chew and end up with nothing accomplished. Especially in the light of Truman's "Fourth Point," the export of American "know-how," this project becomes a prime example of what college students can do in the international line.

More Names

There are a few other articles in this issue too. One of them, "Isotopes and Mass Spectroscopy," seems to show that the equations of 8.03 can be put to use. **Al Kraus,** its author, is "doing" Tech in six terms, course eight to boot, and will graduate in June. His thesis, as one might expect, is to be on the perfect focusing mass spectrometer. **Ken King,** one of *T. E. N.*'s string of new authors, appears in print this issue with his story on Tech's neighbor, Arthur D. Little. Hailing from Pennsylvania, **Ken** will enter Course X. **Bill Lucas,** a transfer from Drexel Tech, is being kept busy at the *T. E. N.* office doing makeup. When we first met him, we thought he would like to handle the article on fluorine which we had planned. To some extent, he agreed with that thought and the result appears on these pages.

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(*Continued from page 7*)

the P. R. I. D. C. no longer considers it necessary to build plants for lease to private manufacturers. Instead, future financial assistance will be limited to mortgage loans made on normal commercial banking terms.

Inducements offered to United States manufacturers to operate branch factories are many: (a) freedom from Federal and insular corporation and property taxes for twelve years, and partial freedom for another three years; (b) low labor costs; (c) freight savings on shipments to the United States and certain other markets; (d) lack of custom duties and other barriers to trade between Puerto Rico and the mainland. Various American manufacturers, satisfied that Puerto Rico offers them excellent industrial opportunities, decided to extend their operations to the Island. For example, Textron, Inc., is now constructing a spindle mill at Ponce and also is planning five additional plants.

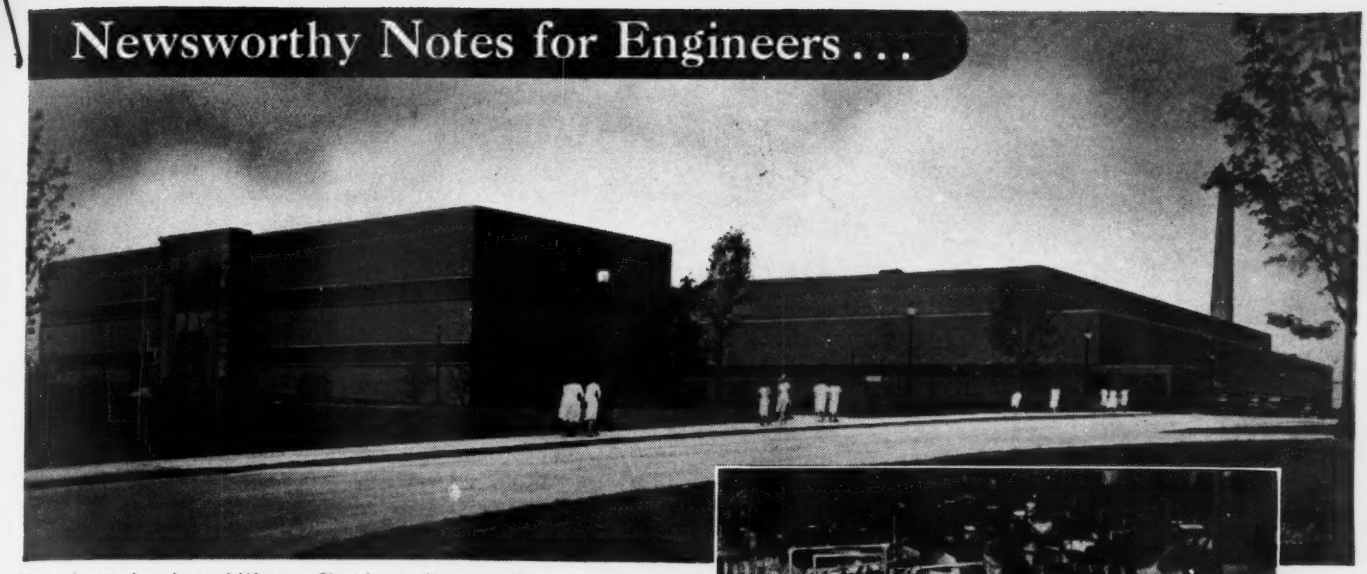
Entrance to Arthur D. Little, Inc., building on Memorial Drive. Here are housed offices and labs of Tech's illustrious neighbor.

Arthur D. Little, Inc., has done much to promote this interest among mainland businessmen by offering technical-economic data to them in order that they may fully realize the potentialities of branch factories in Puerto Rico. Many times such information has caused skeptical executives to consider seriously the expansion of operations to the tax-free Island.

The Development Company did not fail to realize the necessity for trained technical personnel in its program. In fact, eight carefully selected graduate students were sent to the Massachusetts Institute of Technology in 1943. Arthur D. Little, Inc., aided the Institute in the planning of a suitable curriculum for these students. The eight received honor ratings in their studies at Tech and then returned to the Island, where some were assigned to subsidiaries, applying the techniques in which they had specialized. Others became members of the technical staff of the Puerto Rico Industrial Development Company and will ultimately be assigned to the industries about which they studied as soon as the plants are established.

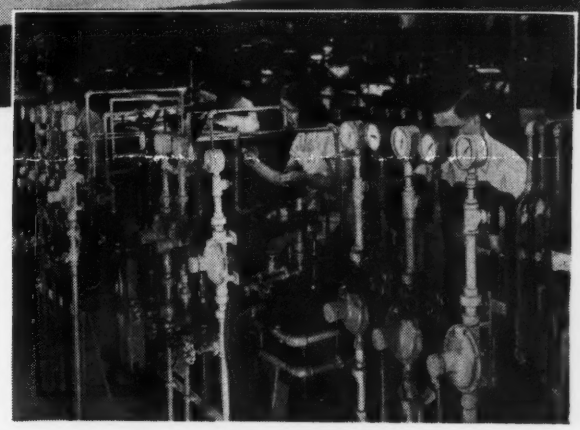
By and large, the growth of industry in Puerto Rico can be attributed to the work of two organizations — the Puerto Rico Industrial Development Company and its general technical consultants, Arthur D. Little, Inc. The importance of the role that the latter plays in the P. R. I. D. C. program can best be realized by considering upon what the industrial expansion of the Island depends: the discovery and utilization of raw materials and the development of their commercial use. That is why the Development Company emphasizes research, development, and construction. Of these three vital bases for progress, Arthur D. Little, Inc., is responsible for the first two. Thus, Tech's neighbor on the Charles is pioneering one of the largest experiments in industrialization ever attempted.

Newsworthy Notes for Engineers . . .



New electronics plant of Western Electric at Allentown, Pa.

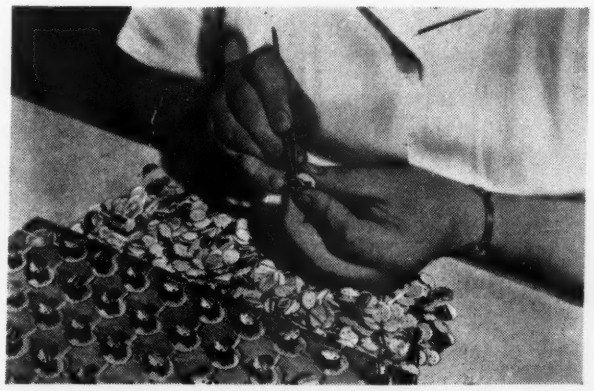
Complex job for Engineers



Over 40 miles of pipes deliver 13 needed services to working locations. These are hydrogen, oxygen, nitrogen, city gas, city water, deionized water, soft water (cold, hot, cooling) high pressure air, low pressure air, process steam and condensate return.

This new "controlled atmosphere" plant, which produces electronic equipment for your telephone service, posed many interesting problems for engineers at Western Electric—manufacturing unit of the Bell System.

For example, a speck of dust or a trace of perspiration may seriously impair the efficiency of vacuum tubes, thermistors, varistors and mercury switches manufactured here. To meet these problems, the new plant is completely air conditioned, with strict control of temperature and humidity—sealed except for doors, and slightly pressurized to keep out dust.



Assembling miniature electron tubes—typical of the high precision work at Allentown—calls for finest lighting. It is provided by a scientifically designed system containing over 13,000 fluorescent tubes.

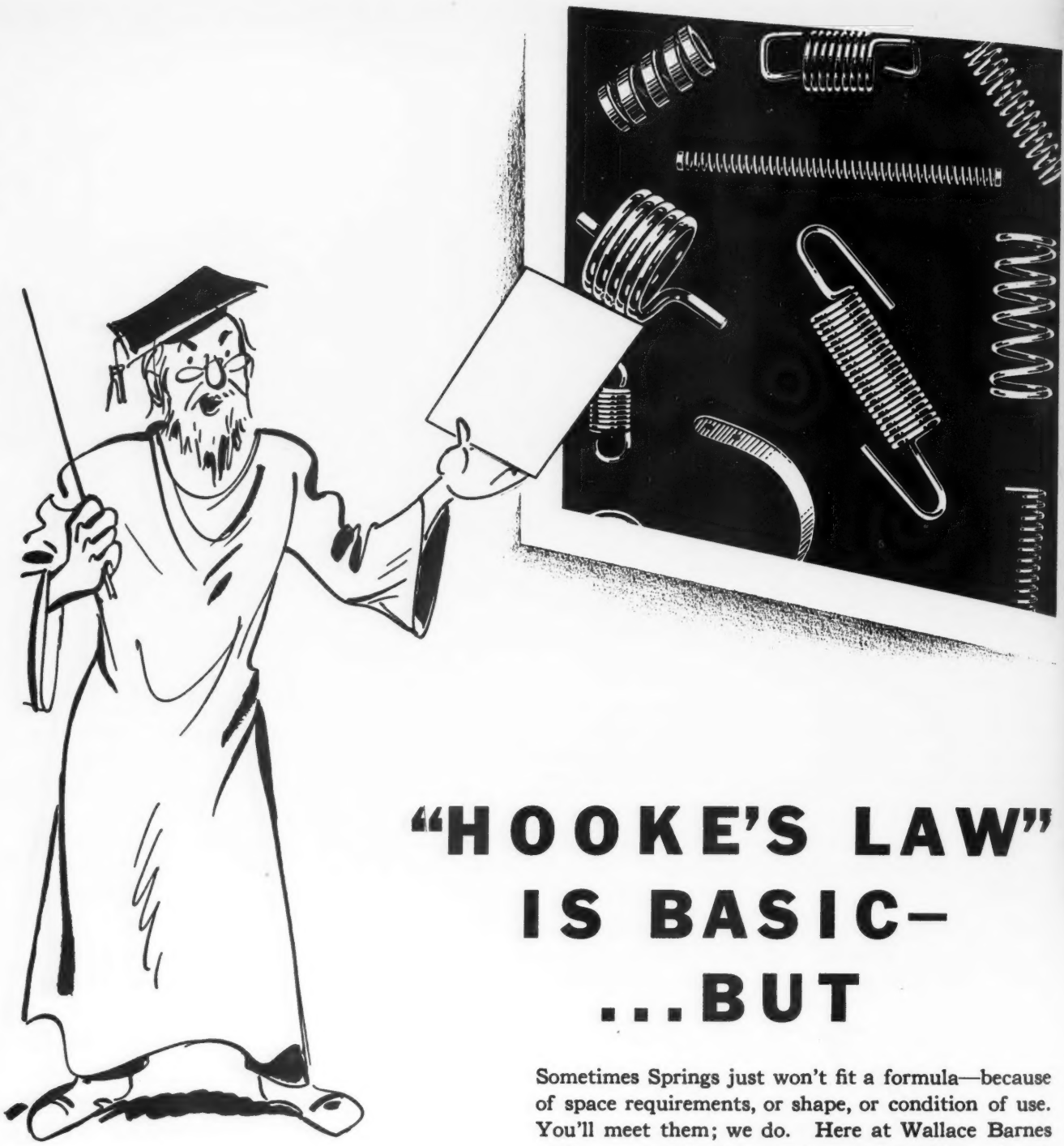
Other "musts" in planning included proper illumination for high precision work—a complex network of piping to deliver 13 needed services—a gas generating plant—a highly efficient chemical waste disposal system.

But beyond the problems solved in helping to design the plant itself, Western Electric engineers met many a challenge in working out highly efficient manufacturing layouts, machine design and production techniques to assure a steady flow of highest quality electronic devices of many types.

This new Western Electric Plant at Allentown is a measure of the ingenuity and thoroughness of Western Electric engineers—electrical, mechanical, industrial, civil, structural, chemical, metallurgical—who provide equipment that helps make Bell telephone service the best on earth.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882



"HOOKE'S LAW" IS BASIC— ...BUT

Sometimes Springs just won't fit a formula—because of space requirements, or shape, or condition of use. You'll meet them; we do. Here at Wallace Barnes we have a practical approach to such problems, based on experienced and specialized skill that should be helpful. Let us show you sometime how this engineering and production service can relieve you of many spring design problems in your chosen field.

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"—They perfect nature and are perfected by experience" —FRANCIS BACON

What these man-made gems mean to you

SYNTHETIC STAR SAPPHIRES like this one, which only the finest of nature's stones can equal, are now made by *man.*

Yes, Union Carbide—which since 1942 has made synthetic crystals for precision instruments and other industrial uses—today produces the loveliest of synthetic star sapphires *and* rubies for personal wear.

But far more important to all of us are the research and technical skills . . . the work with extremes of heat and cold, with vacuums and tremendous pressures . . . that lie behind these superb jewels. The research and skills that produce today's *better materials* . . . used by industry in turning out numberless products.

The same research that brings these man-made stars within our reach . . . brings us, too, man-made leather and rubber. It also gives us today's *better* food, clothing, and shelter. It helps us resist disease. It improves our heating and lighting. It's a part of our swifter, safer transportation systems . . . our communications . . . our progress in construction.

The people of Union Carbide work with a vast range of Alloys, Chemicals, Carbons, Gases, and Plastics. They are constantly perfecting new processes . . . and producing hundreds of materials . . . for the use of science and industry to benefit mankind.

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One-Question Exam On FASTENING

Q. Does it cost more to buy or use fasteners?

A. It's the cost of using a fastener that counts, not the initial purchase price. So the man with the responsibility of buying or specifying fasteners should make sure that *every* function involved in the *use* of bolts, nuts, screws, rivets and other fasteners contributes to the desired fastening result—maximum holding power at the lowest possible *total* cost for fastening.

YOU GET TRUE FASTENER ECONOMY WHEN YOU CUT COSTS THESE WAYS

1. Reduce assembly time with accurate, uniform fasteners
2. Make satisfied workers by making assembly work easier
3. Save receiving inspection through supplier's quality control
4. Design assemblies for fewer, stronger fasteners
5. Purchase maximum holding power per dollar of initial cost
6. Lower inventory by standardizing types and sizes of fasteners
7. Simplify purchasing by using one supplier's complete line
8. Improve your product with a quality fastener

104 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

RB&W
THE COMPLETE QUALITY LINE

Plants at Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, California.

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

AN OKONITE "TWIST" ON CABLE TESTING

Okonite research includes subjecting short lengths of electrical cable to torsion tests (pictured above), twisting them through a spiral arc of 180° under a heavy load.

Bending tests, impact tests, tests of wear-resistance by abrasion — these are a few of the mechanical tests which, along with electrical, chemical and weather-exposure tests, complete an integrated program of performance checks. From its results comes information which Okonite engineers translate again and again into wire and cable improvements that mark major advances in the field. The Okonite Company, Passaic, New Jersey.

S171

OKONITE insulated wires and cables
OKONITE SINCE 1878

chlorine's sister grows up

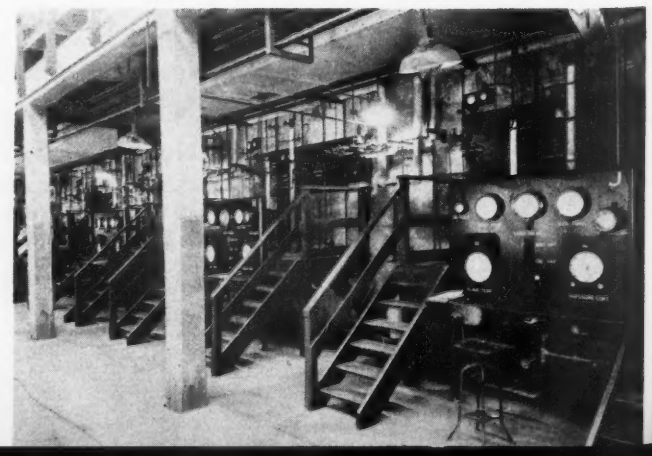
(*Continued from page 17*)

tions, showed almost no corrosion at 400 degrees and less than copper at higher temperatures. The passive coating of fluoride which is thought to protect these metals and magnesium also is more adherent than that which forms on ferrous metals when exposed to fluorine. Iron and steel, for that matter, will easily burst into flame in an atmosphere of the gas, especially when heated by a local flare-up of grease or other organic matter which happens to be on the metal when the fluorine attacks. Metals whose surface fluoride layers are continually broken by friction also corrode at greatly increased rates.

When water or organic compounds are present,

(*Continued on page 32*)

This battery of controls regulates the conditions under which fluorination reactions are carried out in the Hooker Electrochemical Company's plant.



New RCA 16-inch direct-view television tube fills gap between popular 10-inch tubes and the projection-type receivers.

"Inside story" of a bigger, brighter picture on your television screen

The screen on which you are accustomed to seeing television is the face of an electron tube—on which electrons "paint" pictures in motion.

And the size of the picture, unless projected, is determined by the size of the tube.

Working to give you *bigger*, brighter pictures, RCA engineers and scientists developed a new way to make large, direct-view television tubes. They found a method of "welding" large areas of glass and metal . . . while keeping a vacuum-tight seal!

Using this development—ideally suited to mass production—RCA can now build television tubes of light, tough metal . . . using polished glass for the face, or "screen."

An achievement of research

Development of this new way of making television tubes is a continuation of *basic television research* which began at RCA Laboratories. Such leadership in science and engineering adds *value beyond price* to any product or service of RCA and RCA Victor.

. . .

Examples of the newest advances in radio, television, and electronics—in action—*may be seen at RCA Exhibition Hall, 36 W. 49th St., New York. Admission is free. Radio Corporation of America, Radio City, N. Y. 20.*

Continue your education with pay—at RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

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  Options: Pure and Applied Mathematics
           Industrial Statistics
Physical Biology
Physics
Quantitative Biology

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  Options: Heavy Construction
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Business and Engineering Administration
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           Illumination Engineering
           Electrical Communications
           Electronic Applications

Electrical Engineering
  Co-operative Course

General Engineering

Marine Transportation

Mechanical Engineering
  Options: General Mechanical Engineering
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Metallurgy
  Options: Metallurgy
           Mineral Dressing

Meteorology

Naval Architecture and Marine Engineering

The duration of each of the above undergraduate Courses is four academic years, with the exception of Architecture, Food Technology (Five Year Course), Physical Biology, and the Co-operative Courses in Electrical Engineering and in Mechanical Engineering, which extend over a period of five years. In addition to the Bachelor's degree, the above five year courses, with the exception of Architecture, lead also to the Master's degree.

Graduate study, leading to the Master's and Doctor's degrees, is offered in Ceramics and in most of the above professional Courses.

A five year Course is offered which combines study in Engineering or Science, and Economics. This leads to the degree of Bachelor of Science in the professional field, and to the degree of Master of Science in Economics and Engineering or Economics and Natural Science.

For information about admission, communicate with the Director of Admissions. The Catalogue for the academic year will be sent free on request.

When Does An Engineer Finish Exams?

The answer, of course, is never—*not as long as he continues to be an engineer.* As an engineer, every problem put to you, in school and out, will always test your professional skill and ingenuity. The next step, then, is to *make sure you'll always pass.*

Today you're passing those exams with the information you're getting out of books, lectures and the laboratory. Tomorrow, when you are out on the job, the lectures and the laboratory will be gone. But your engineering books will always be there, and to them you will add the business and technical magazines devoted to your special branch of work.

Many of the books you are using now and will use throughout your career bear the McGraw-Hill imprint, for McGraw-Hill is the world's leading publisher of technical and scientific works. Pick up the writings of an authority in your branch of engineering and there's a good chance they were published by McGraw-Hill, for McGraw-Hill books are the works of the leaders in technology and science.

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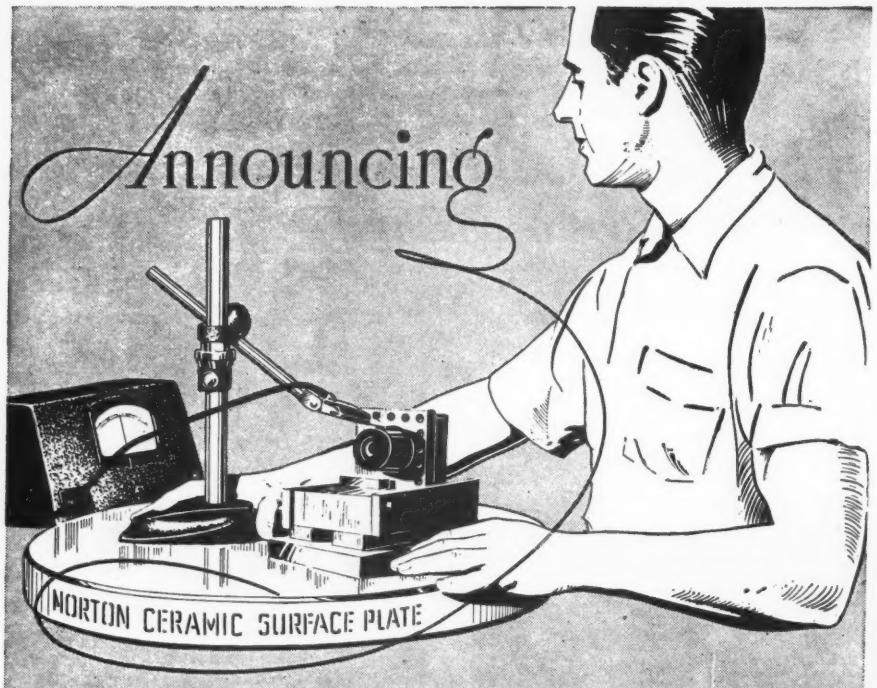


Another NORTON "FIRST"

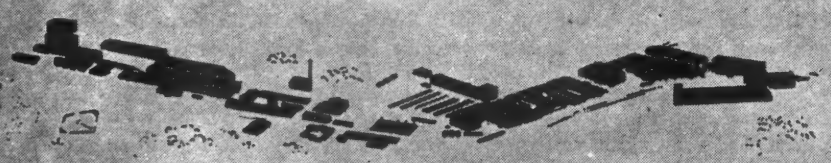
THIS time it's a *ceramic* surface plate—an entirely new type of plate for toolmakers and inspectors to use in making their precise measurements. This Norton-developed ceramic plate has distinct advantages over previous types of surface plates including: (1) a longer-lived surface, (2) a smoother surface, (3) a flatter surface and one that *stays* flat. It will not warp nor deform, not sweat nor corrode, not deflect under load.

The development of this unique surface plate is typical of the progressive research that has made Norton an acknowledged leader—not only in abrasives and grinding wheels but also in the development of grinding and lapping machines, high temperature refractories and a wide variety of wear-resistant materials.

In the Norton laboratories at Worcester, Chippawa and Troy, there are 195 scientists, engineers and technicians constantly at work on new or improved Norton products.

NORTON COMPANY, WORCESTER 6, MASS.

Behr-Manning, Troy, N. Y., is a Norton Division



The main Worcester plant of Norton Company—world's largest producer of abrasive products

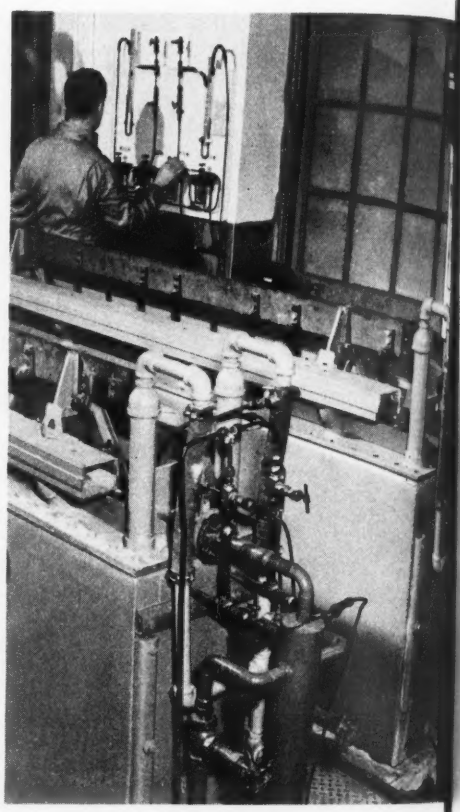
NORTON

ABRASIVES — GRINDING WHEELS — GRINDING AND LAPPING MACHINES
REFRACTORIES — POROUS MEDIUMS — NON-SLIP FLOORS — NORBIDE PRODUCTS
LABELING MACHINES (BEHR-MANNING DIVISION: COATED ABRASIVES AND SHARPENING STONES)

chlorine's sister grows up

(*Continued from page 28*)

corrosion varies from the above data. Organic compounds, if not fluorinated, will be ignited by contact with the gas and the heat generated may raise the metal above its kindling point. If water is present, the problem is one of resistance to both fluorine and hydrogen fluoride, since fluorine reacts with water. With hydrogen fluoride, again, nickel, Monel, copper, and Inconel show best resistance at 500 to 600 degrees.



These 1500–2000-ampere cells generate sixty to eighty pounds of fluorine each per day at the plant of the Pennsylvania Salt Manufacturing Co.

Industrial utilization of fluorine necessarily involves such items as pumps and valves. Resistant metals are here not sufficient, since lubrication and packing are also necessary. At this point, the fluorinated hydrocarbons and the fluorine-carbon polymeric plastics enter the picture.

As has been mentioned, fluorinated hydrocarbons are extremely stable substances. When every hydrogen atom on a carbon chain is replaced by fluorine, the perfluoro compound, as such a compound is known, is an extremely stable sub-

(*Continued on page 34*)

Summer Opportunities

with

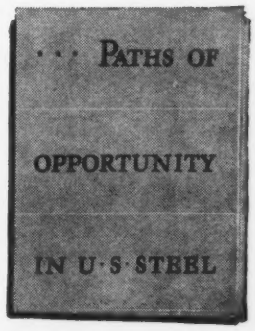
UNITED STATES STEEL

and how they can affect your future

UNITED STATES STEEL CORPORATION SUBSIDIARIES are now selecting a limited number of outstanding engineering students for summer employment. This temporary work has been designed to provide students with practical experience that will supplement their regular college curriculum. This work may also prove a valuable guide to the student in choosing his life work following graduation.

The activities of U. S. Steel Subsidiary Companies are so diversified that they require qualified men in just about every branch of engineering. And every effort is made to place these students in permanent positions with U. S. Steel after graduation.

Your Placement Officer can give you additional information about summer employment with United States Steel. Why not discuss the matter with him and at the same time ask him for a copy of the book—"Paths of Opportunity in U. S. Steel."



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USS

UNITED STATES STEEL

PROBLEM: You are designing a valve grinding machine. You have to provide a drive for the chuck that holds the valve stem. This chuck must be adjustable in three different directions. Your problem now is to devise a method of driving the chuck which permits these adjustments. How would you do it?

THE SIMPLE ANSWER: Use an S.S.White power drive flexible shaft to transmit power to the chuck. The shaft provides a positive, dependable drive that permits free movement of the chuck in any direction.

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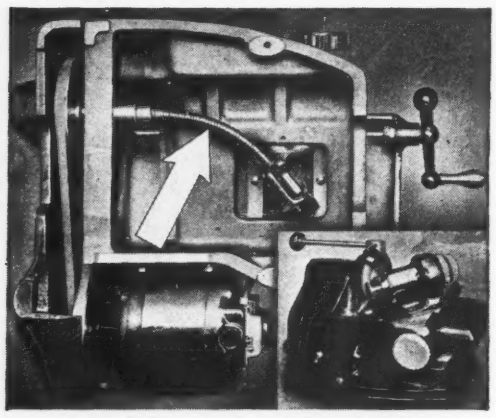
This is just one of hundreds of remote control and power drive problems to which S.S.White flexible shafts provide a simple answer. That's why every engineer should be familiar with the wide range and scope of these useful "Metal Muscles"* for mechanical bodies.



This is how one large manufacturer did it.

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It gives essential facts and engineering data about flexible shafts and their application. A copy is yours free for asking. Write today.

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Adaptable to many special applications such as sorting and quality control devices. Simple setting provides readings of .0001" to .00001". Intermediate settings can be made easily to match prescribed tolerance limits. Equipment includes: amplifier unit; external and internal comparators; gage head cartridge for jig or fixture mounting; signal light attachment. Write for catalog. Brown & Sharpe Mfg. Co.,

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BROWN & SHARPE

chlorine's sister grows up

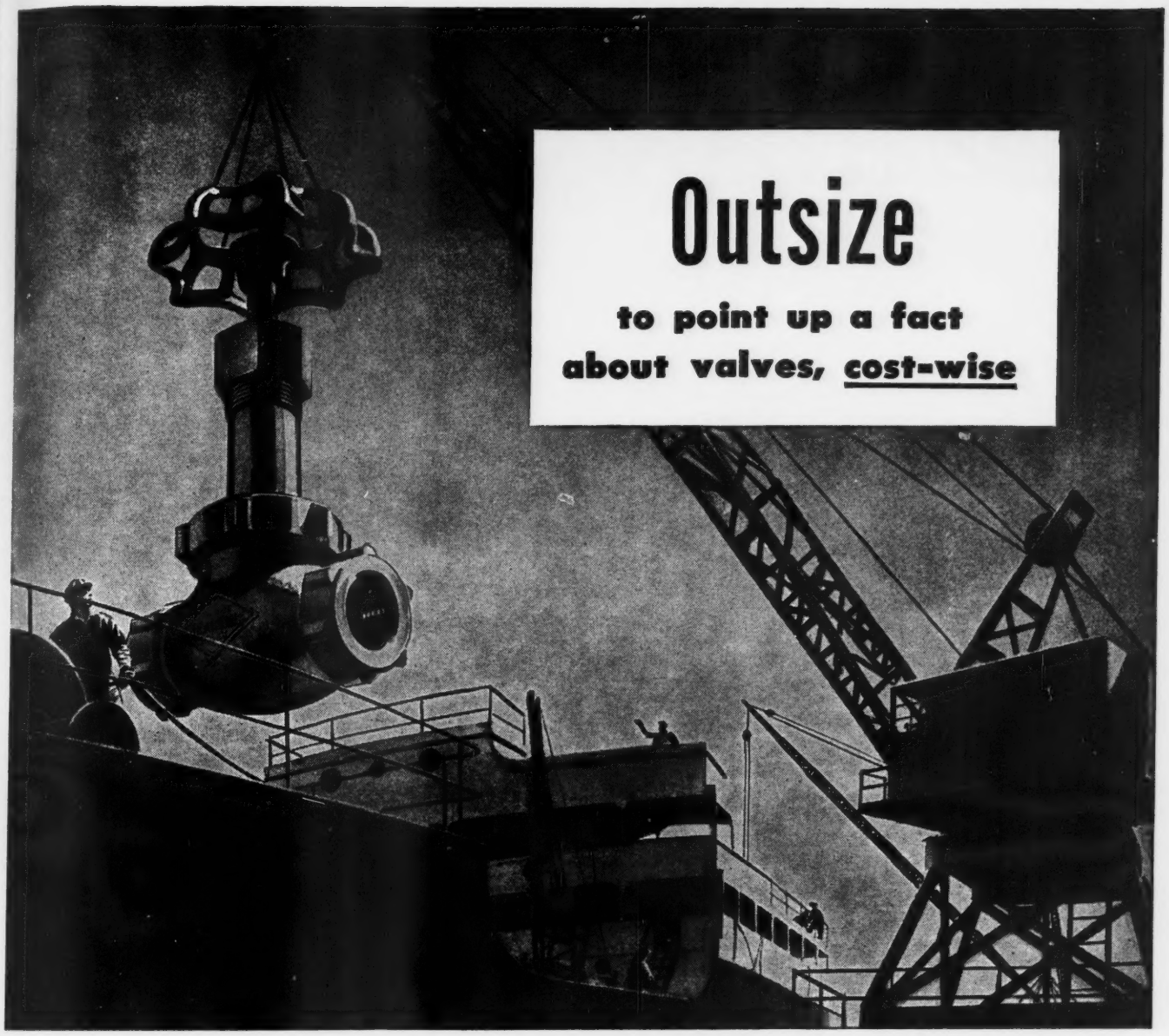
(*Continued from page 32*)

stance. A compound known as polytetrafluoroethylene and marketed as "Teflon" is such a substance. "Teflon" can withstand temperatures above 300 degrees for long periods of time and is unaffected by hot aqua regia or boiling solvents, a feat possible to no other present-day plastic. Owing to these properties, it has been used as valve packing in equipment handling fluorine. However, in its production, only long carbon chains can be obtained and these have the disadvantage of being hard to work into useful shapes. This difficulty has been overcome to some extent by another polymer known as "Kel-F," which contains one atom of chlorine for every two carbon atoms, the rest of the molecule being composed of fluorine. "Kel-F" is formed by a polymerization reaction which may be halted at any desired stage to give substances ranging from oils to thermo-plastics with softening points as high as 350 degrees. Other hydrocarbon plastics which are not fully fluorinated are progressively less stable but offer the advantages of lower cost and easier working.

Although chlorine derivatives of hydrocarbons may be prepared by direct reaction with chlorine, such a process is impossible with fluorine, since the heat of the ensuing reaction is sufficient completely to disrupt the molecule. As a result, reagents such as cobalt trifluoride and silver difluoride have been developed as fluorinating agents.

The physiological properties of fluorine offer another obstacle to its use on a large scale. Both fluorine and

(*Continued on page 38*)



NO SHIP was ever fitted with a valve this big. We took broad liberties with proportion in this picture because a valve's size can be misleading. In comparison with larger plant units, the cost of a single valve seems a minor, "petty cash" investment. But if, as here, *all* the valves could be viewed as *one* valve, you would see that valves actually represent a *major* expenditure.

In any plant, any building where operation involves fluid control, it pays management to keep this "collective" valve in mind. These days, especially. They pay more than ever today, in wages and material costs, for every operation in the plant — including valve maintenance.

EXCESSIVE MAINTENANCE of one inferior valve is insignificant, but multiplied by *thousands*, it is a serious drain on operating budgets.

JENKINS BROS. helps to meet this problem. In *two* ways. One, by building extra endurance into Jenkins Valves. They are the longest-lasting, lowest-upkeep valves that money can buy. Two, with advice from Jenkins Engineers on any question of proper selection, installation, or maintenance.

For all new installations, for all replacements, alert management relies on Jenkins quality and engineering for lowest valve costs in the long run. *Sold through leading Industrial Distributors.*

Jenkins Bros., 80 White St., New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco. Jenkins Bros., Ltd., Montreal.

"PREVENT VALVE FAILURE" is a 28-page guide to valve economy, fully illustrated, with case histories of valve damage, and recommendations for its prevention by proper selection, installation, inspection, and maintenance. FREE on request. Write JENKINS BROS., 80 White St., New York 13, N. Y.

LOOK FOR THIS JENKINS DIAMOND MARK

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JENKINS VALVES

Types, Sizes, Pressures, Metals for Every Need

Variety of Equipment used by

SUPERIOR METAL TREATERS, INC.

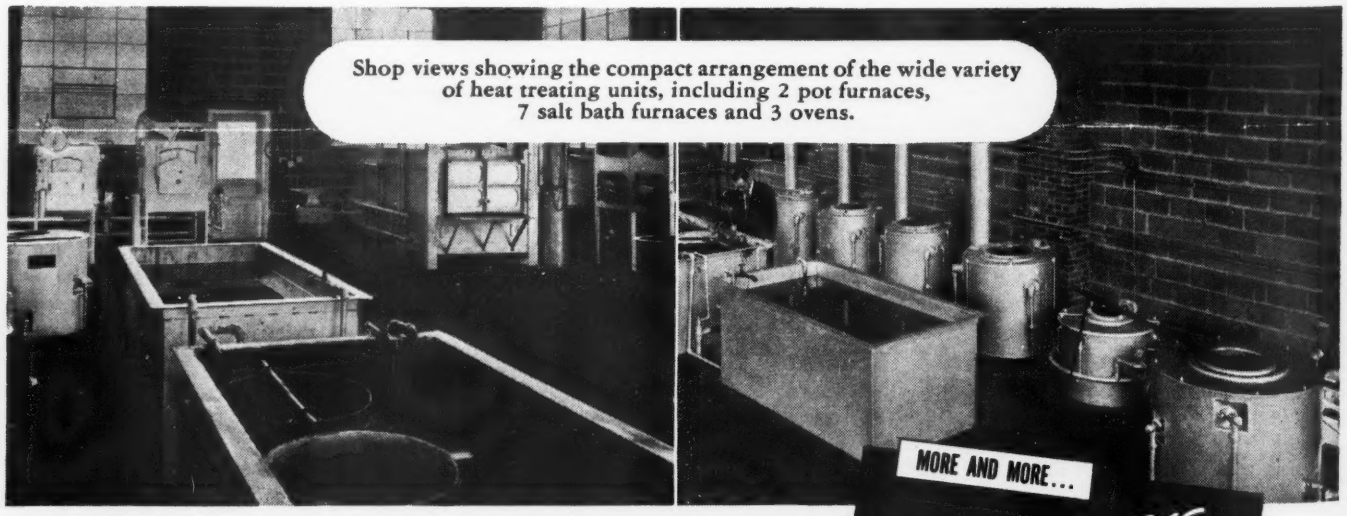
Emphasizes the Versatility of GAS

VARIETY is one of the most characteristic features of a commercial heat treating shop—variety of customer demands and variety of equipment required to fulfill them.

With a background of 22 years experience, Evan D. Ehmann, President of Superior Metal Treaters, Inc., knew just what to look for when he established his Newark, New Jersey, shop. This modern plant has the productive capacity to cope with the miscellaneous requirements of many customers.

Key feature of the installation is the versatility of the equipment. Each unit was chosen for its ability to perform under a number of different conditions. In selecting this equipment Mr. Ehmann determined to use GAS because, as he expresses it, **"During my years in this business I discovered that Gas Equipment provided the accurate control, economical operation, and versatility we needed. The precise temperatures and speed of heating we obtain with GAS mean a lot of extra production in our shop."**

Whether the heat treating process is a production-line application, or a commercial shop operation, the flexibility of GAS and the versatility of modern Gas Equipment are important economic factors. The characteristics of GAS make it stand out in any comparison with other available fuels for heat processing.



Shop views showing the compact arrangement of the wide variety of heat treating units, including 2 pot furnaces, 7 salt bath furnaces and 3 ovens.

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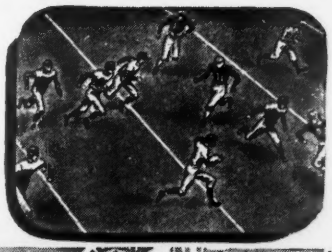

Plastics where plastics belong

for high dielectric and structural strength, light weight and ease of machining

In the RCA television camera, for example, Synthane was selected for coil forms, tubes, flanges and other components because of its electrical insulating properties, especially at high frequencies and high voltages. Its ease of machining, light weight and structural strength were other factors that led RCA's design engineers to select Synthane as the best possible material for this job.

Synthane, laminated phenolic plastic, is at its best in applications requiring unusual *combinations* of characteristics. Its excellent electrical insulating ability, combined with ease of machining, light weight, rigidity and many other properties, such as moisture and corrosion resistance, make Synthane a valuable material for many industries.

Synthane Corporation, 1 River Road, Oaks, Pennsylvania

SYNTHANE *where Synthane belongs*

SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

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K & E drafting instruments, equipment and materials have been partners of leading engineers for 81 years in shaping the modern world. So extensively are these products used by successful men, it is self-evident that K & E has played a part in the completion of nearly every American engineering project of any magnitude.

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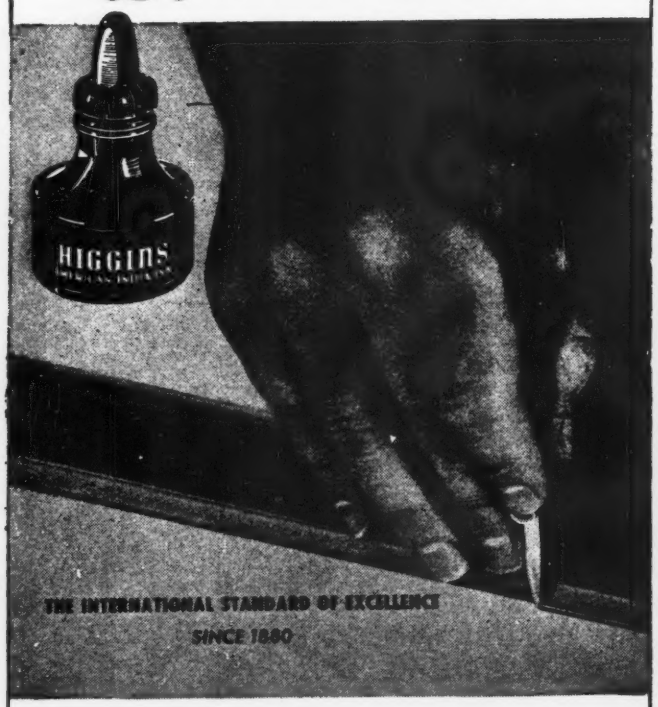
Lay it on the line



You'll always win

HIGGINS INK CO., INC. 271 NINTH STREET, BROOKLYN 15, N. Y.

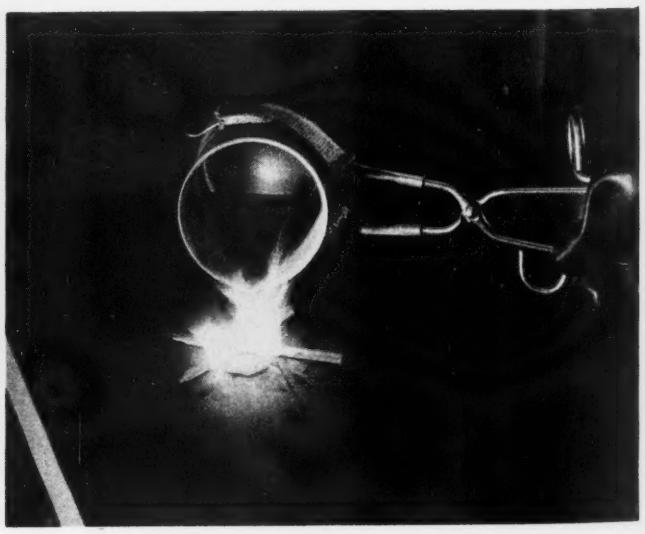
chlorine's sister grows up

(*Continued from page 34*)

hydrogen fluoride are highly corrosive, and human flesh is not exempt from their action. Although it might be expected that fluorine burns would resemble thermal burns, due to the highheats involved in the element's reactions, such burns more resemble the corrosive effect of the acid. Although under some conditions several hours may elapse before a burn becomes painful, it eventually becomes red, then pale and swollen. A highly efficient treatment has been developed which consists in washing with large quantities of water and an application of magnesium hydroxide paste if the burn is mild. The corrosive effects of fluorine and hydrogen fluoride have a strong tendency to penetrate deeply into the flesh and further treatment is often required. If the burn is serious, the surrounding area is infiltrated with a solution of calcium gluconate to precipitate the fluorine as calcium fluoride. This treatment not only halts further injury but greatly reduces pain.

From corrosive fluorine and hydrofluoric acid, through toxic sodium fluoroacetate, to fluoroform, which is so stable that it has been substituted for nitrogen in atmosphere breathed by guinea pigs, is quite a jump, but fluorine bridges it. The commercial development of fluorine is expected to bring new advances in almost every field allied to chemistry.

Chlorine trifluoride similar to fluorine in many respects causes a block of wood to burst into flame almost on contact. *Courtesy Pennsalt*



"You THINK you know what Roebling makes...

you stand there talking about Roebling wire cloth and screening. Well I tell you Roebling makes *electrical wire and cable*. I've bought them since before you were born!"

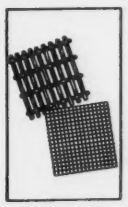
• • • •

Of course both engineers are right. At its four big plants in and near Trenton, New Jersey, Roebling makes an extremely wide variety of wire and wire products . . . develops new types and achieves quality standards of highest efficiency and service economy to industry.

ROUND — FLAT — SHAPED WIRE. Every inch of Roebling high carbon wire is just like every other inch in gauge and temper, grain structure and finish. That means fewer rejects, fewer stoppages . . . production speed and lowered costs... It's available *now!*

WIRE ROPE. Roebling wire rope is a standard specification in many industrial fields. Among the large variety of types, Roebling Preformed "Blue Center" Steel Wire Rope is outstanding for easy handling, operating efficiency and economical service cost.

ELECTRICAL WIRE — CABLE — MAGNET WIRE. With 65 standard types to choose from, there's a Roebling Electrical Wire or Cable for all transmission, distribution and service requirements . . . For high-speed winding you'll find Roevar Magnet Wire is tops.



WOVEN WIRE FABRIC. Roebling industrial Screens range from finely woven Filter Cloths (including highly corrosion-resistant types) to largest Aggregate Screens. Roeflat Screen, a new development, has 75% more wearing surface . . . gives up to 90% more wear.

Whatever career you are studying for, when you get on the job you will find one or more types of Roebling products serving there, dependably and at low cost. John A. Roebling's Sons Company, Trenton 2, New Jersey.

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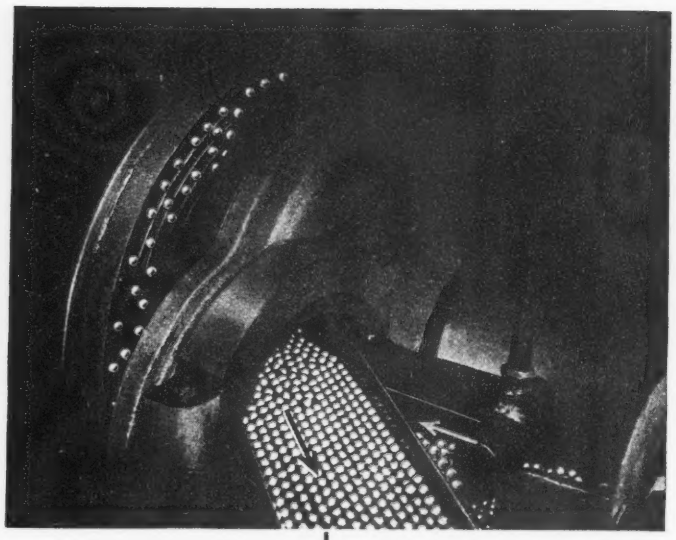
P-1806 Job 4224-64 Proof 3, 2-16-49

FACTS ABOUT SKF

HOW BALLS ARE MADE ROUND!



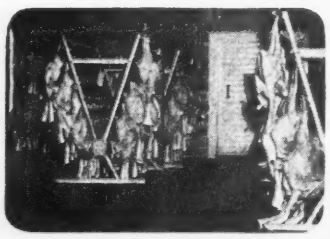
The making of steel balls is similar in principle to Grandma's method of forming and rolling butter between two paddles. In large lots, the balls are put through a succession of grinding machines, each machine doing a finer job than the last, until accuracy of one 25-millionth of an inch has been achieved. SKF Industries, Inc., Philadelphia 32, Pa. 6591

SKF
BALL & ROLLER BEARINGS

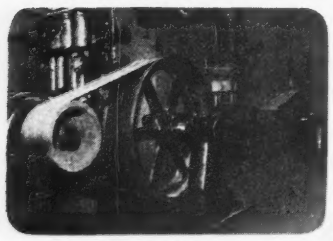
● *Send for a free copy of Catalog No. 263, "How Are Balls Made Round?"*

Unloading one of the 15 Frick Blizzard Freezers at Mt. Vernon, Wash. Temperature is 40° below 0. Installed by Lewis Refrigeration & Supply Co., Seattle.

Quick-freezing 80,000 Pounds of Poultry with FRICK Refrigeration



Precooling Poultry at 33° F.



Two of Five Frick Compressors

That's just one day's work at the new plant of the Washington Co-Operative Farmers Assn. But it means 16,000 chickens or 4,000 turkeys have to be processed, precooled, quick-frozen, and stored at zero.

Frick Refrigeration carries the entire cooling load at this Mt. Vernon, Washington plant—just as it does in the world's largest quick-freezer, across the continent at Bridgeton, N. J.

If you're anywhere in between, and need refrigeration, get in touch with the nearest Frick Branch Office.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, Offers a Career in a Growing Industry.

DEPENDABLE REFRIGERATION SINCE 1882
FRICK CO.
WAYNESBORO, PENNA. U.S.A.

fields, curves, and particles

(*Continued from page 21*)

cosine of α can be considered as unity, but the particles will not stay on the axis. Then with l fixed,

$$m = \left(\frac{lq}{2\pi v_0}\right) B.$$

If B is known when the ions focus at P, the mass can be calculated. This system has been used by Witcher to investigate β rays.

Yet this system has second order focusing only to the extent that the cosα is unity. Using this same basic principle, however, a system of theoretically perfect focusing can be obtained. If instead of giving the particles motion along the B axis, they are given uniform motion perpendicular to it, the resultant paths will be cycloidal. This type of motion is the same as that of a point of a wheel that rolls on a level surface. Figure 7 shows three types. Curve a represents the point on the wheel at a distance from the center less than the radius. Curve b is for a point on the circumference. Curve c is for a point at a distance from the center greater than the radius.

To get the particles to travel in such paths, a field configuration of type two is set up as in figure 8. Now we let the particles start at the origin with an x component of velocity v_{x_0} and a y component v_{y_0}. The equations of motion are

$$m\frac{d^2x}{dt^2} = qB\frac{dy}{dt}$$

$$m\frac{d^2y}{dt^2} = qE - qB\frac{dx}{dt}.$$

(*Continued on page 44*)

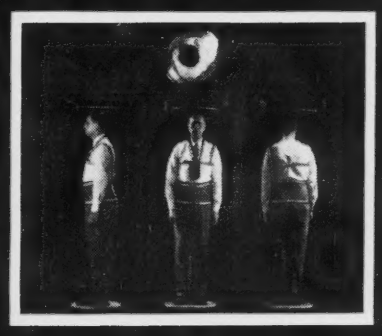
All size 42
—yet no two alike

Now, photography with its speed and accuracy measures a man for his clothes quickly and with precision in every dimension.

Recently a striking new idea hit the headlines—an idea aimed at fitting made-to-measure clothes more accurately than ever before. It was the idea of Henry Booth of Amalgamated Textiles, Ltd., and he named it "PhotoMetric."

In the PhotoMetric method, photography scans you with a wink of its precise eye from before, behind, above, and from the side. With the click of a shutter it gets all major measurements plus all the individual variations from a "perfect" size. It oversteps the limitations of the tape and records contours, proportions, shape, and posture as well.

Later, in the pattern room, the film is projected and, in effect, there you stand while the craftsman with special calibrated devices measures your image in three dimensions—getting some thirty highly accurate readings.



PhotoMetric installations are already going in from coast to coast. It is a fine example of how photography is serving business, science, and industry—speeding methods, refining technics, improving products. It may be well worth your while to look into what the photographic process can do for you.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

Advancing business and industrial technics—

Functional Photography

Kodak

briefing the news

Warmer Light . . .

The highly efficient but cold, blue light produced by the mercury vapor lamp can now be improved by increasing the amount of red light which it transmits. In the past it had been found necessary either to intersperse mercury lamps with incandescent lamps or to add metals such as cadmium or zinc to the mercury lamp. Both of these measures resulted in lowered efficiency.

The solution was found to lie in coating of the inner surface of the mercury lamp with a high-temperature phosphor. This coating, through fluorescence, transforms invisible ultra-violet into visible red light. The resultant light is eight times richer in red light than the illumination the uncoated mercury lamp can produce.

The phosphor coating of this lamp is a special mixture which fluoresces at a temperature of 750° F.

Congealed Gasoline . . .

The technique of congealing gasoline and then reconverting it for use has now been perfected by the Quartermaster Corps of the United States Army.

There are many advantages to be gained by this congealing process. Congealed gasoline will not explode and is difficult to ignite. For these reasons it may be stored in open bins or shipped in ordinary freight cars without fear of combustion.

Any petroleum product such as kerosene, fuel oil, or gasoline can be converted to a solid or semi-solid state without alteration of its original characteristics. The congealed fluid can then be reconverted to the fluid state by compression.

X-Ray Image . . .

An electronic tube has been developed which increases by a factor of five hundred the potential brightness of the image seen on an X-ray fluoroscope. (The fluoroscope is a machine which provides a direct X-ray view without the need of photography.)

The new "image amplifier" is the product of six years of research. The operation is as follows: X-rays, after having passed through the object or person being viewed, strike a fluorescent screen, from which they release light rays. These light rays strike a photo-sensitive surface on the other side of the screen, thereby causing this surface to emit electrons. The electrons, after crossing the tube, hit a second fluorescent screen. This action releases the light rays which form the image seen by the observer.

Gas Detection . . .

Bloodhounds are now being successfully used in the detection of gas. The problem of detecting gas leakages has long been a difficult one. Perhaps the most widely used method has consisted in the artificial odorization of natural gas in order to make it strong enough to stimulate the human olfactory nerve. This method is satisfactory for household leak detection but is very poor in the case of the many miles of buried gas mains.

Odorants are usually injected into the gas system at a continuous rate of one pound for every million cubic feet of gas. This provides a concentration which is more than sufficient for the household and which can be detected by bloodhounds even when it has escaped from a buried gas main.

The only other method which heretofore existed for detecting such underground leaks was the use of a combustion meter. This process involves having a crew of men follow a gas line with a probe bar digging holes to the main at ten-foot intervals. Air-gas samples are then brought to the surface and tested by the combustion meter. Using this expensive method the average crew can cover only three city blocks in a day.

On the other hand a bloodhound crew could cover over seven miles in a day and would not cost as much.

The efficiency of these dogs has been thoroughly tested in the following ways: First, it was found that they were capable of detecting and locating as little as a few drops of solution in an acre of ground. They become very excited upon finding such a spot and refuse to leave the place until their find has been acknowledged. In fact, the dogs not only discovered the test odor spots but also discovered leaks whose existence was not even suspected by the testers.

The dogs further proved their ability by going over a three-mile gas line in Monroe, Louisiana, which had just been checked by the conventional combustion meter. Here again the dogs not only caught every leak detected by the meters, but also discovered a few others. Thus it appears that the "meters with noses" will be a most valuable aid in this field.

(*Continued on page 44*)

DU PONT Digest
For Students of Science and Engineering

Chemists in Pictures

How Du Pont and studio scientists solved the problem of noisy film

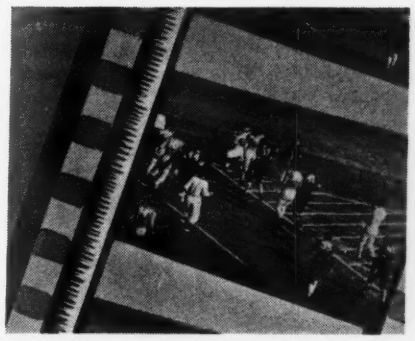
Who'd ever expect to find Du Pont chemists in Hollywood? When motion pictures suddenly started to talk, a whole new series of perplexing scientific problems was born, not the least of which was "noisy" film.

As you know, sound is usually recorded directly on film. If you hold a strip of motion picture film to the light, the sound track is seen as a narrow band of irregular lines. A light ray passing through the moving sound track falls on a photocell with rapid interruptions or changes in intensity. The photocell converts these interruptions into electrical impulses which, amplified, reach the theater audience as voice and music.

If the film has a coarse grain structure, it tends to give lines that are not sharp and uniform in density. Such irregularities interrupt the light ray—come out as distracting noise.

What could be done about it? Du Pont scientists of the Photo Products Department started a program of research, in cooperation with technical experts from the studios in Hollywood. They made and tested scores of film coatings. Finally there were developed films of exceedingly fine grain structures.

M-G-M and Paramount were among the first to use the new type Du Pont films. The development was heralded by the press as "another milestone in the technical progress of the industry," and in 1943 Du Pont



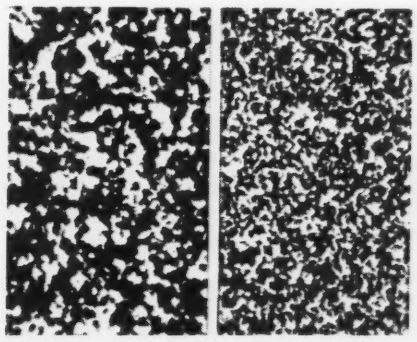
Voice and music *appear as a continuous band of irregular lines on this movie sound track. Any irregularity means noise.*

received an Academy Award of Merit for its achievement. Now the use of fine grain films is practically universal in Hollywood. Actors. actresses speak their lines, with no technical restrictions to cramp their artistry.

You may have a place in Du Pont research

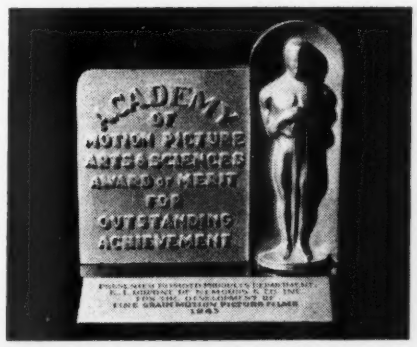
Had you been a member of a Du Pont Photo Products research team since 1931, you might have shared in many outstanding achievements, two of which have been recognized by "Oscars."

W. L. Foy, *Ph.D. in Physical Chemistry, Clark University, 1947, and A. C. Lapsley, Ph.D. in Physics, Virginia, 1947, discussing details of Color Densitometer Wiring Diagram used in connection with research on color photography.*



In coarse grain films, *the particles of silver are large and scattered. Compare with Du Pont fine grain film, right. (Magnified 1000 times.)*

The Photo Products Department, however, is just one of ten Du Pont manufacturing departments, all of which engage in continuous research. Operated much like separate companies, each holds challenging opportunities for young, college-trained chemists, engineers and physicists. Du Pont not only tries to select young men and women of promise, but makes a conscientious effort to help each one develop as rapidly as possible. Whatever your interests, you will find here the cooperation and friendly interest you need to do your best. As a member of a small, congenial working team, your ability can be seen, recognized and rewarded.



Achievements *of Du Pont scientists over the years have won two "Oscars" from Academy of Motion Picture Arts and Sciences.*

Don't miss reading this new booklet about Du Pont

Send for your copy of "The Du Pont Company and the College Graduate." This fully illustrated, 40-page booklet answers your questions, describes many fields which may be new to you. Tells about opportunities in research, production, sales, etc. Explains how recognition of ability is assured. For free copy, address: 2518 Nemours Bldg., Wilmington 98, Delaware.

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More facts about Du Pont— Listen to "Cavalcade of America" Monday Nights, NBC Coast to Coast

WRITE TODAY for "The Du Pont Company and the College Graduate"

briefing the news

(*Continued from page 42*)

Dry Printing . . .

A fourth method of printing has been added to those already in existence. Xerography, or dry printing, substitutes powder for ink. Images are formed by the powder under pressure of static electricity. Surface electrical charges substitute for printing faces. The process is applicable to smooth surfaces such as metal, cloth, or ceramic materials and is especially suited for color work.

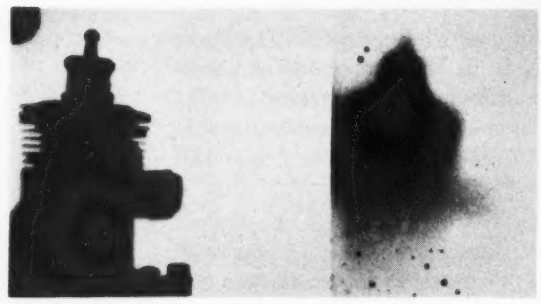
In the process, a layer of photoconductive material, such as sulfur, is given an electrical charge and is exposed through the material to be printed. A powder sprinkled on the exposed, charged surface adheres then only to the unexposed portions and can be fused to form a permanent image. Presses using the process should be able to run as rapidly as conventional presses.

Heat Photos . . .

The Eastman Kodak Co. has announced a method of photographing heat radiation with the aid of phosphor screens. The phosphors used are highly sensitive to heat radiation and glow in the dark, permitting photographic recording of the heats of objects in a wide range of temperatures, extending as low as that of the human hand. A curved metal mirror is utilized to focus the radiation on the screen which produces an image of the object against its background of different temperature. A piece of ice has thus been photographed simply because it radiates less heat than the surrounding air. The photographs on this page show a similar photograph of a model airplane engine, in contrast to a shadowgraph of that engine.

Light for Nothing . . .

A patent has recently been granted on a fluorescent light which uses no electrical current. The light consists of a bulb, coated with a suitable fluorescent material, containing a small quantity of mercury and a little of one of the rare gases. When the globe is shaken, light is produced, opening up applications in equipment subject to constant vibration. An indefinite life is claimed for the bulb.



fields, curves, and particles

(*Continued from page 40*)

Letting

$$\omega = \frac{qB}{m},$$

and integrating these we get

$$x = \frac{1}{\omega}\left(V_{x_0} - \frac{E}{B}\right) sin\ \omega t + \frac{V_{y_0}}{\omega}(1 - cos\omega t) + \frac{E}{B}t,$$

$$y = \frac{1}{\omega}\left(\frac{E}{B} - V_{x_0}\right)(1 - cos\ \omega t) + \frac{V_{y_0}}{\omega} sin\ \omega t.$$

These give the initial conditions at $t = 0$. Now at $\omega t = 2\pi$,

$$x = \frac{E}{B}\frac{2\pi}{\omega} = \frac{2\pi E}{qB^2}m,$$
$$y = 0.$$

Thus regardless of the initial velocities in the xy plane, all of the particles go through the point $(2\pi Em/qB^2, 0)$. Then since there is no need of any velocity or second order focusing, we have perfect focusing. Bleakney and Hipple used this system in 1938.

At the present time the most accurate instruments use double focusing methods, that is, second order focusing by use of some radial electrical field and focusing according to mass by some magnetic field. Doubtlessly the most fruitful research is along this vein. However it is possible that Goudsmit's time of flight spectrometer or a perfect focusing scheme may prove to be as good.

count with your fingers

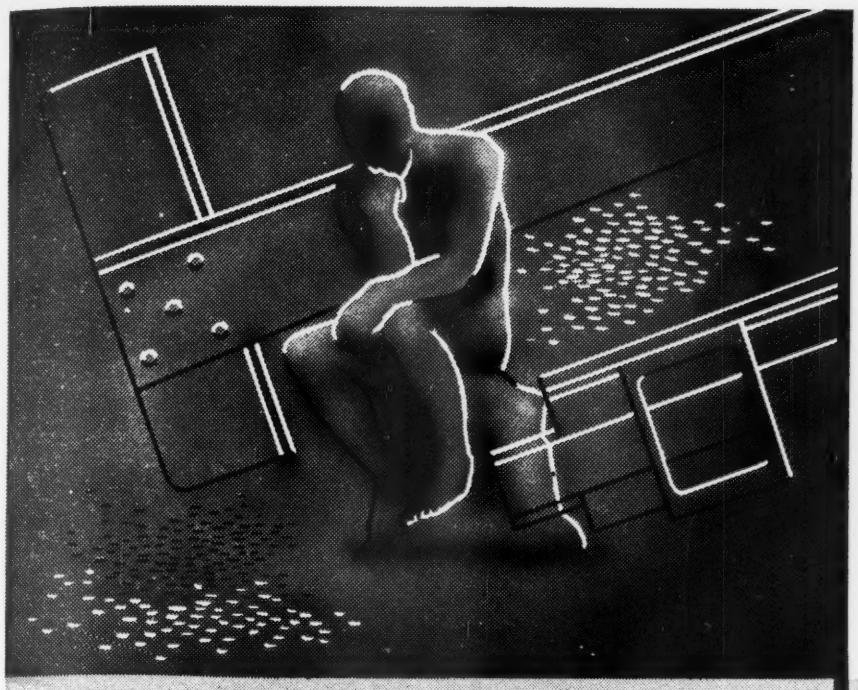
An M. I. T. student has learned to count to thirty using just his ten fingers! First he counts to five on one hand. Then, to represent this five, he puts up one finger on the other hand. This process can be repeated four more times, giving a sum of twenty-five. However, he is not finished yet — he can use the first hand for another five units and end up with a final thirty.

This trick is not so wonderful, however. If our student were eager enough, he could imitate one type of the many electrical or mechanical analyzers and calculators and use the binary system of counting, in which there are only two digits — one and zero — in place of ten.

Using the binary system, one can count up to $2^n - 1$, excluding zero, where n is the number of counting elements — stones, sticks, or what-have-you. Therefore on one hand he can count up to $2^5 - 1$ or thirty-one. If our human approach to an abacus uses both hands, he can reach 1023, while if he takes off his shoes and uses both ears, he can reach the grand sum of four million, one hundred ninety-four thousand, three hundred three!

ALFRED A. KRAUS, JR., '49

If anyone who happens to read this has any piece of information, puzzle, or the like, which he feels might be of interest, and can put into letter form, T. E. N. will be interested in printing it in a form similar to the above. Ed



Thinking of improving

"Improving" any machine really means increasing its productive capacity. That means tinkering with speeds and weights and strength—ending up with alloy steels.

Which alloy steel?—the one that meets physical requirements at the lowest cost. Molybdenum steels fill that bill. Good hardenability, plus freedom from temper brittleness, plus reasonable price enable them to do it.

Send for our comprehensive 400-page book, free; "MOLYBDENUM: STEELS, IRONS, ALLOYS."

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS

Climax Molybdenum Company
500 Fifth Avenue · New York City

MOLY

C2

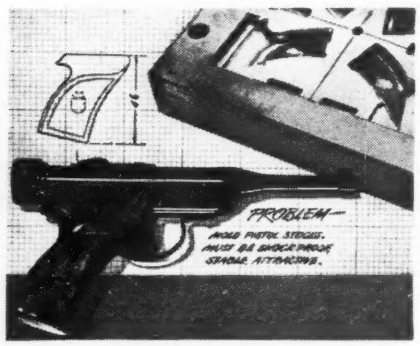
. . . a great name in research with a big future in CHEMISTRY

PLASTICS—A MULTIMILLION-DOLLAR INDUSTRY AND STILL GROWING

"Plastics" to most people connotes something modern—something new. And the plastics industry, as it now exists, is still an infant, but a lusty and vigorous one.

How fast it has grown in a short span of years is indicated by these figures, which show the number of plastics molding plants in the United States in the last thirty-nine years:

1910	8 plants
1920	63 plants
1930	172 plants
1940	575 plants
1949	1,160 plants (estimated)



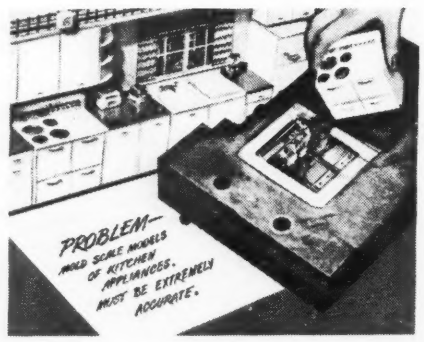
The Ancients Molded Plastics

But the art of casting "plastic" material in molds is an old one. As long ago as King Solomon's time, asphalts and mineral tars were being molded into useful shapes.

These natural molding materials were the only ones available for centuries—until the invention, in 1869, of the first modern synthetic plastic, celluloid. Today the plastics industry makes dozens of synthetic materials with a wide range of molding characteristics.

General Electric entered the plastics business more than fifty years ago by molding carbon rods for arc lamps from clay and lampblack. Later, G. E.'s plastics operations expanded rapidly, when plastics began to be used extensively in electrical insulation.

As General Electric's plastics operations grew, it became practical to offer plastics services to other companies.



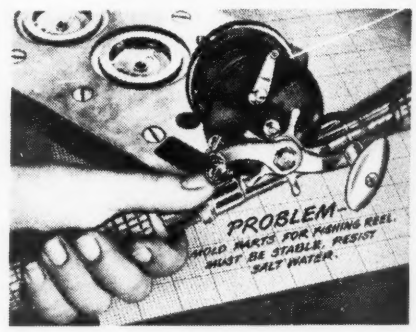
Now General Electric is unique in the industry, being both a manufacturer of plastics molding materials and one of the world's largest plastics molders.

G. E. provides a complete plastics service. It has facilities for producing special types of molding compounds and for designing, engineering, and molding any kind of plastics part or product.

You may breakfast at a dinette table with a surface of G-E Textolite* (a laminated sheet plastics); your toaster may have a base of plastics, molded by G. E.; the breakfast service may be G-E plastics plates and cups in beautiful pastel shades. Your automobile, your refrigerator, your radio, your camera—all are likely to incorporate plastics parts produced by General Electric.

The Scope of G-E Chemical Department's Operations

Molded plastics are just one part of General Electric's Chemical Department's operations. Other products made and sold by the Chemical Department include the amazing new materials of organic-silicon chemistry called silicones, Glyptal* alkyd resins, insulating varnishes, permanent magnets, and plastics molding compounds. Every month new chemical developments are coming from the G-E research laboratories. And the variety and scope of G-E chemical operations promise to broaden tremendously as this research progresses.



For more information, write Chemical Department, General Electric Company, Pittsfield, Massachusetts.

A message to students of chemistry from

F. W. WARNER

Engineering Manager of the G-E Plastics Division

The rapid growth of the plastics industry in the last ten years offers us some idea of the progress we may expect in plastics within the next decade. For a young man who wants to "grow up" with a rapidly expanding business, the field of plastics seems to offer particularly attractive opportunities.

*REG. U. S. PAT. OFF.

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PLASTICS • SILICONES • INSULATING MATERIALS • GLYPTAL ALKYD RESINS • PERMANENT MAGNETS • MOLDING COMPOUNDS